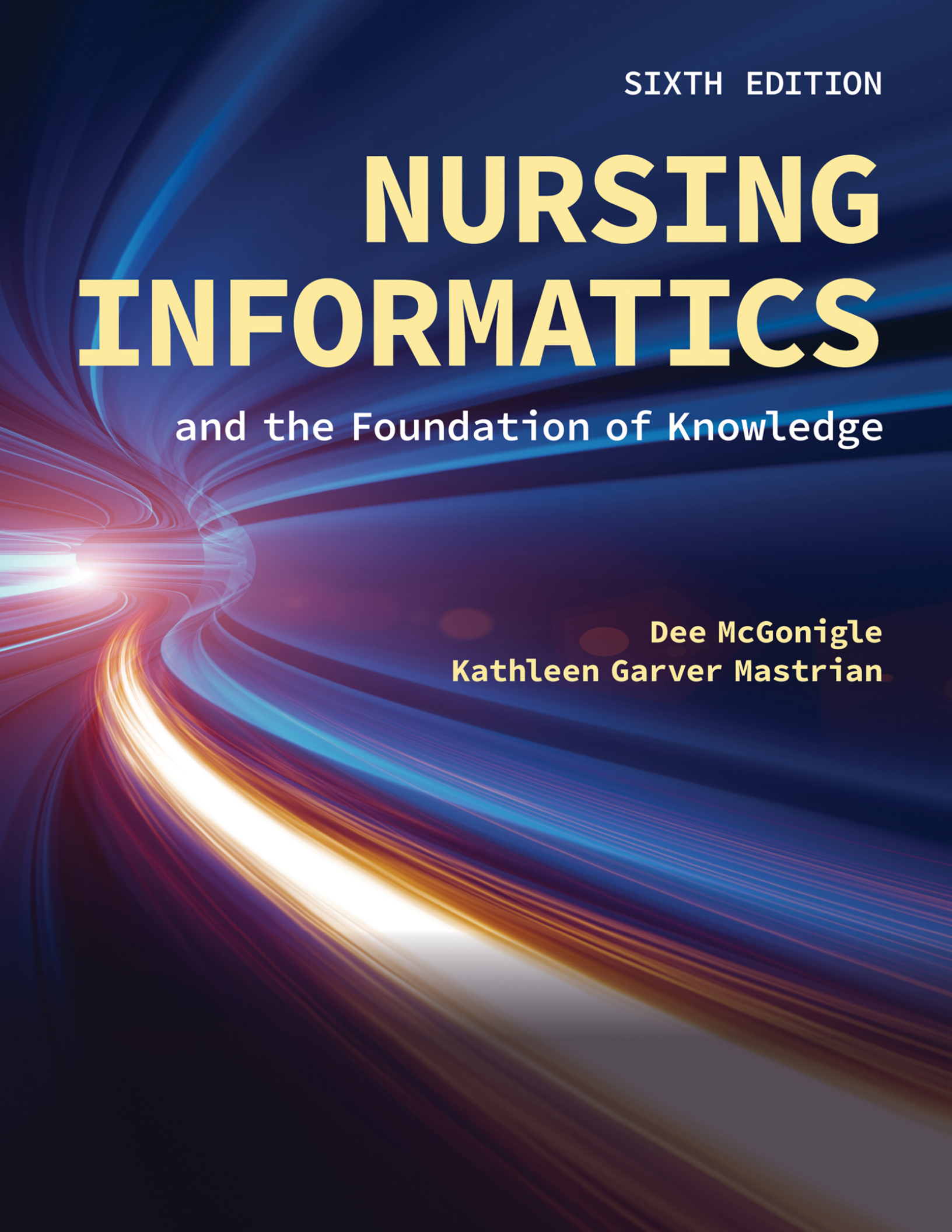
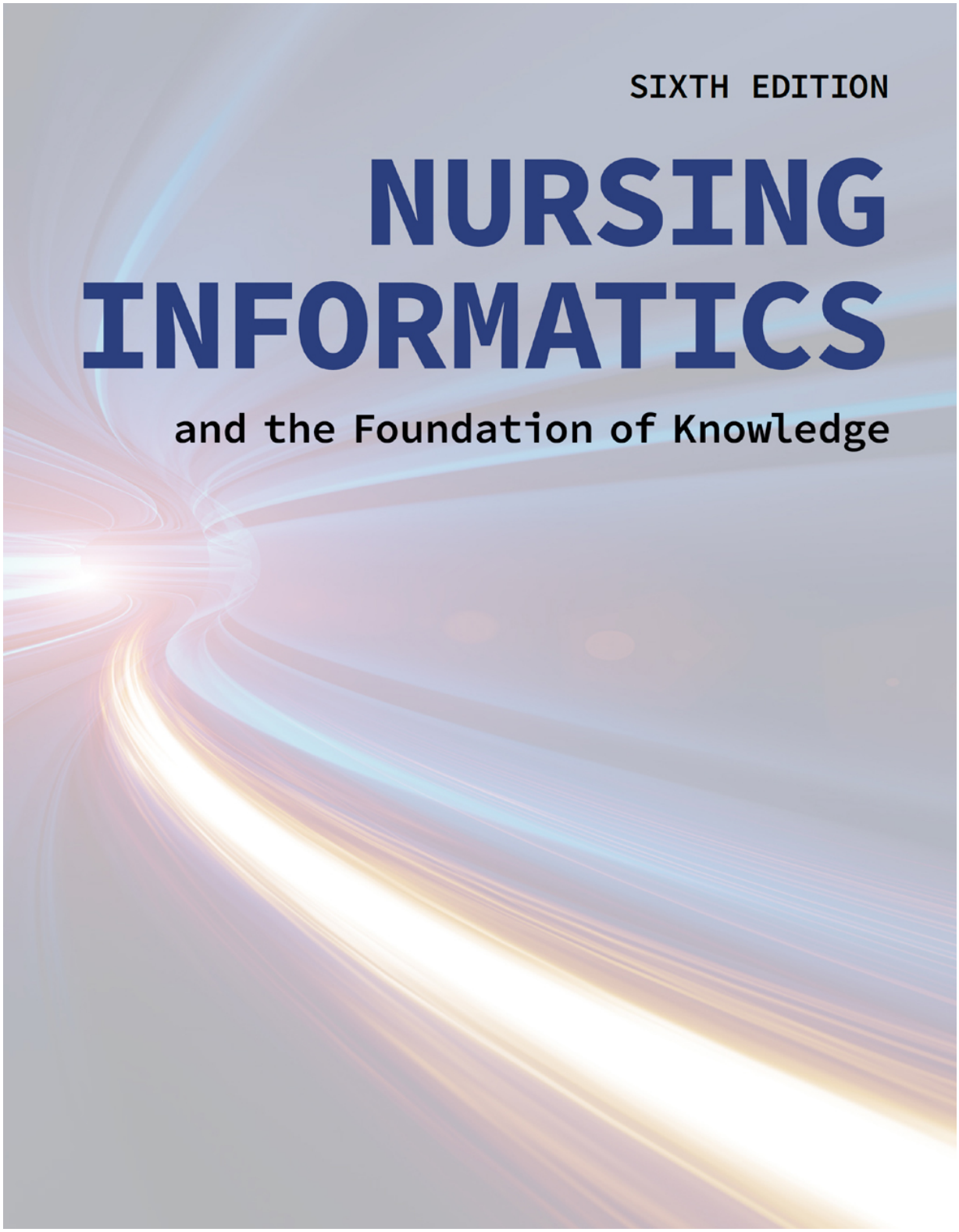

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and the Foundation of Knowledge
Dee McGonigle
Kathleen Garver Mastrian


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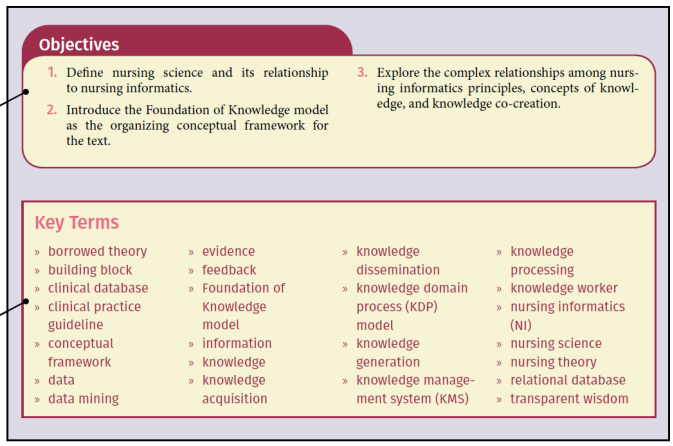
The Pedagogy

Nursing Informatics and the Foundation of Knowledge, Sixth Edition, drives comprehension through a variety of strategies geared toward meeting the learning needs of students while also generating enthusiasm about the topic. This interactive approach addresses diverse learning styles, making this the ideal text to ensure mastery of key concepts. The pedagogical aids that appear in most chapters include the following:

Objectives The objectives provide a snapshot of the key information encountered in each chapter. They serve as a checklist to help guide and focus study. Objectives can also be found within the text's online resources.

Key Terms Key terms are found in a list at the beginning of each chapter. Studying these terms will create an expanded vocabulary.

Introductions An introduction is found at the beginning of each chapter. The introduction provides an overview highlighting the importance of the chapter's topical area. It also helps keep students focused as they read.

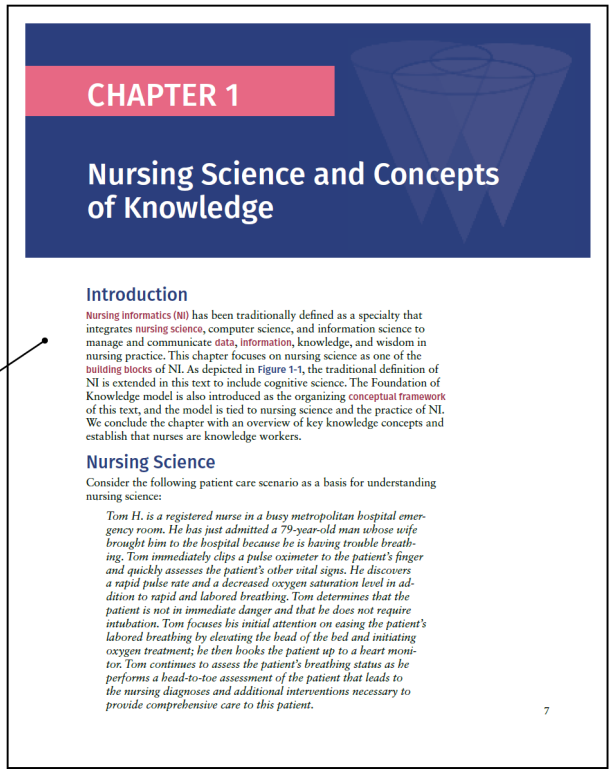


Objectives

1. Define nursing science and its relationship to nursing informatics.
2. Introduce the Foundation of Knowledge model as the organizing conceptual framework for the text.
3. Explore the complex relationships among nursing informatics principles, concepts of knowledge, and knowledge co-creation.

Key Terms

- borrowed theory
- building block
- clinical database
- clinical practice guideline
- conceptual framework
- data
- data mining
- evidence
- feedback
- Foundation of Knowledge model
- information
- knowledge
- knowledge acquisition
- knowledge dissemination
- knowledge domain process (KDP) model
- knowledge generation
- knowledge management system (KMS)
- knowledge processing
- knowledge worker
- nursing informatics (NI)
- nursing science
- nursing theory
- relational database
- transparent wisdom



CHAPTER 1

Nursing Science and Concepts of Knowledge

Introduction

Nursing informatics (NI) has been traditionally defined as a specialty that integrates nursing science, computer science, and information science to manage and communicate data, information, knowledge, and wisdom in nursing practice. This chapter focuses on nursing science as one of the building blocks of NI. As depicted in Figure 1-1, the traditional definition of NI is extended in this text to include cognitive science. The Foundation of Knowledge model is also introduced as the organizing conceptual framework of this text, and the model is tied to nursing science and the practice of NI. We conclude the chapter with an overview of key knowledge concepts and establish that nurses are knowledge workers.

Nursing Science

Consider the following patient care scenario as a basis for understanding nursing science:

> *Tom H. is a registered nurse in a busy metropolitan hospital emergency room. He has just admitted a 79-year-old man whose wife brought him to the hospital because he is having trouble breathing. Tom immediately clips a pulse oximeter to the patient's finger and quickly assesses the patient's other vital signs. He discovers a rapid pulse rate and a decreased oxygen saturation level in addition to rapid and labored breathing. Tom determines that the patient is not in immediate danger and that he does not require intubation. Tom focuses his initial attention on easing the patient's labored breathing by elevating the head of the bed and initiating oxygen treatment; he then hooks the patient up to a heart monitor. Tom continues to assess the patient's breathing status as he performs a head-to-toe assessment of the patient that leads to the nursing diagnoses and additional interventions necessary to provide comprehensive care to this patient.*

RESEARCH BRIEFS

CONSUMER PERCEPTIONS OF HEALTH INFORMATION ON THE WEB

Using an online survey of 1,227 randomly selected respondents, Bodkin and Miaoulis (2007) sought to describe the characteristics of information seekers on eHealth websites, the types of information they seek, and their perceptions of the quality and ethics of the websites. Of the respondents, 74% had sought health information on the web, with women accounting for 55.8% of the health information seekers. A total of 50% of the seekers were between 35 and 54 years of age. Nearly two thirds of the users began their searches using a general search engine rather than a health-specific site, unless they were seeking information related to symptoms or diseases. The top reasons for seeking information were related to diseases or symptoms of medical conditions, medication information, health news, health insurance, locating a doctor, and Medicare or Medicaid information. The level of education of information seekers was related to the ratings of website quality in that more educated seekers found health information websites more understandable but were more likely to perceive bias in the website information. The researchers also found that the ethical codes for eHealth websites seem to be increasing consumers' trust in the safety and quality of information found on the web but that most consumers are not comfortable purchasing health products or services online.

ETHICS AND CONSUMER ENGAGEMENT IN NURSING

Hassmiller and Bilazarian (2018) explored consumer engagement and its relationship to safety, quality, and ethics to identify promising practices and leadership strategies. The literature review was supplemented with interviews from 25 key nursing informants. They described examples illustrating business, ethical, and quality cases and noted that we must pay attention to all three types of cases for the synergy needed for optimal clinical effectiveness and consumer engagement. Interviewees highlighted the ethics cases and the idea that nurse leaders have an ethical responsibility to lead in the area of consumer engagement by committing to the values of compassion, patient advocacy, and consumer engagement and translating those values to the patient. It was important to note that technology can add to or detract from opportunities for engagement with consumers based on the use of the tools and the amount of disruption. This study identified strategies and organizational changes necessary to enhance partnering with healthcare consumers while supporting the quality and safety, business, and ethics cases needed for consumer engagement.

Research Briefs Research briefs are summaries of research meant to encourage students to access current research in the field.

Inserts These highlighted inserts provide the reader with more detailed information and points to ponder.

BOX 16-2 ARTIFICIAL INTELLIGENCE (AI) APPLIED AS A PATIENT ENGAGEMENT STRATEGY

In the competitive and confusing healthcare delivery system of today, it is important that providers be able to personalize each patient's experience. Open communication is key to remaining current with the needs of patients while making them feel connected to the practice and satisfied with the care they receive. In a blog post on Seismic (2017), it was stated that "[w]hen it comes to patient engagement, the promise of AI is to improve the experience by anticipating patient needs, providing faster and more effective outcomes" (para. 7). Seismic recommended the following:

- Engaging patients with insights that are conversational and contextual, and adjusting based on the situation to respond in real time.
- Teaming providers with the intelligent guidance of AI so they can provide patients with next-best actions, personalized to them.
- Empowering patients who want to actively participate and engage in their health with intelligent guidance and support when needed. (para. 7)

The blog post stated it best:

> *A smart machine might be able to diagnose an illness and even recommend treatment better than a doctor; however, it takes a person to sit with a patient, understand their life situation, and help determine which treatment plan is optimal.* (para. 9)

Heath (2019) stated that a "survey of 2,000 healthcare consumers and 200 business decision makers (BDMs) revealed that AI may soon be the future of patient care" (para. 2). AI must not only engage patients but also engage healthcare providers and facilitate their ability to provide healthcare. Marr (2018) stated that AI can help with critical thinking, clinical judgment, image analysis, robotic-assisted surgery, and diagnosing. He also described providing virtual nursing assistants to monitor patients and facilitate communication and information exchange between face-to-face visits. Heath (2018) discussed the high patient satisfaction scores when patients are provided virtual care: "[F]orty-seven percent of patients said they prefer a more immediate, virtual care encounter than having to wait for an encounter that is in person" (para. 7). AI in the form of virtual nursing assistants can help patients feel connected and engaged in their care.

Reflect on the following AI virtual patient encounter; assume each role (nurse, Craig, and patient, Mary), and assess your perspective as each one. The AI virtual nurse is known as Kate.

Working Wisdom

Since the beginning of the profession, nurses have applied their ingenuity, resourcefulness, and professional awareness of what works to adapt technology and objects to support nursing care, usually with the intention of promoting efficiency but also in support of client comfort and healing. This resourcefulness could also be applied effectively to the adaptation of information technology within the care environment, to ensure that the technology truly does serve patients, nurses, and the rest of the interprofessional team.

Consider this question: How can you develop competency in using the various computer hardware and software not only to promote efficient, high-quality nursing care and to develop yourself professionally but also to further the development of the profession's body of knowledge?

Application Scenario

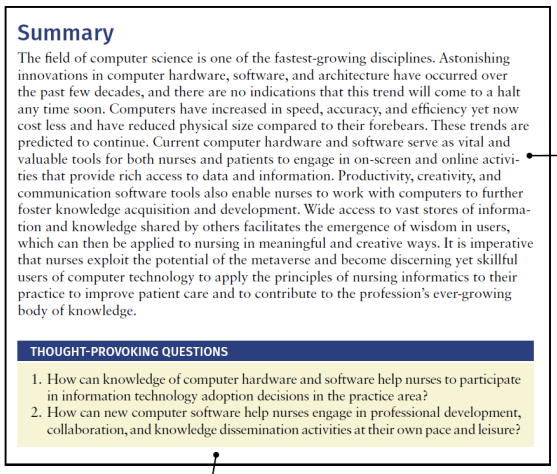
Dan P. has just been accepted into the nursing informatics graduate program. In the past, he has used his 8-year-old laptop to surf the World Wide Web, exchange email with friends, and play computer games. Now, however, Dan realizes that the computer is a vital tool for his academic success, and he has saved up enough money to purchase a new laptop computer and the necessary accessories he needs to be successful. He knows that his program will entail VR and that the university has launched their public metaverse space. What questions should he ask of his nursing advisor before he decides on the laptop he should purchase? Dan reached out to his nursing advisor, Dr. Smythely, and she sent Dan a list of general university and program-specific technical requirements needed for his success (see Box 3-3).

After completing this chapter, how would you answer the following questions?

1. Dan is set on purchasing a new laptop. Where is his money best spent and why? Would it be better to get the most memory, the fastest processor, the most storage, or the latest operating system?
2. Dan is excited about VR but does not have a clue about which HMD would be best let alone how much they cost. Since he does not know anything about the headsets, what should he do to make an informed decision?

Working Wisdom Working wisdom allows the reader to experience an expert's practical application of knowledge and experience as they address specific situations such as walking the reader through an expert's application of the ETHICAL model or the experts' feedback in the 10 interactive case studies.

Application Scenarios Application scenarios allow the reader to see how the concepts or information can be applied to authentic or real-world situations.



Summary

The field of computer science is one of the fastest-growing disciplines. Astonishing innovations in computer hardware, software, and architecture have occurred over the past few decades, and there are no indications that this trend will come to a halt any time soon. Computers have increased in speed, accuracy, and efficiency yet now cost less and have reduced physical size compared to their forebears. These trends are predicted to continue. Current computer hardware and software serve as vital and valuable tools for both nurses and patients to engage in on-screen and online activities that provide rich access to data and information. Productivity, creativity, and communication software tools also enable nurses to work with computers to further foster knowledge acquisition and development. Wide access to vast stores of information and knowledge shared by others facilitates the emergence of wisdom in users, which can then be applied to nursing in meaningful and creative ways. It is imperative that nurses exploit the potential of the metaverse and become discerning yet skillful users of computer technology to apply the principles of nursing informatics to their practice to improve patient care and to contribute to the profession's ever-growing body of knowledge.

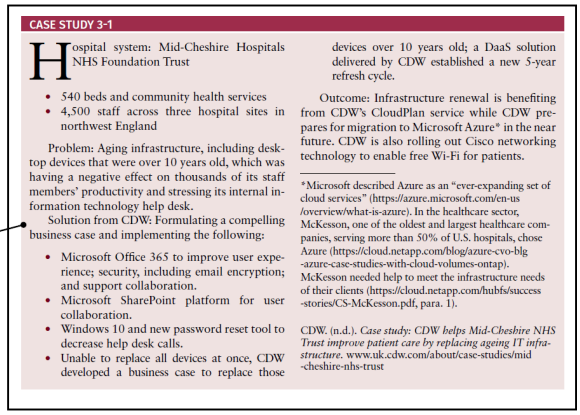
THOUGHT-PROVOKING QUESTIONS

1. How can knowledge of computer hardware and software help nurses to participate in information technology adoption decisions in the practice area?
2. How can new computer software help nurses engage in professional development, collaboration, and knowledge dissemination activities at their own pace and leisure?

Summaries A summary is included at the end of each chapter to provide a concise review of the material covered. The summary highlights the most important points and describes what the future holds.

Thought-Provoking Questions Students can work on these critical thinking assignments individually or as a team activity. In addition, students can delve deeper into concepts by completing these exercises online.

Case Studies Case studies are authentic, encourage active learning, and promote critical thinking skills. Students can ask questions, analyze situations, and solve problems in a real-world context.



CASE STUDY 3-1

Hospital system: Mid-Cheshire Hospitals NHS Foundation Trust

- 540 beds and community health services
- 4,500 staff across three hospital sites in northwest England

Problem: Aging infrastructure, including desktop devices that were over 10 years old, which was having a negative effect on thousands of its staff members' productivity and stressing its internal information technology help desk.

Solution from CDW: Formulating a compelling business case and implementing the following:

- Microsoft Office 365 to improve user experience; security, including email encryption; and support collaboration.
- Microsoft SharePoint platform for user collaboration.
- Windows 10 and new password reset tool to decrease help desk calls.
- Unable to replace all devices at once, CDW developed a business case to replace those devices over 10 years old; a DaaS solution delivered by CDW established a new 5-year refresh cycle.

Outcome: Infrastructure renewal is benefiting from CDW's CloudPlan service while CDW prepares for migration to Microsoft Azure* in the near future. CDW is also rolling out Cisco networking technology to enable free Wi-Fi for patients.

*Microsoft described Azure as an "ever-expanding set of cloud services" (https://azure.microsoft.com/en-us/overview/what-is-azure). In the healthcare sector, McKesson, one of the oldest and largest healthcare companies, serving more than 50% of U.S. hospitals, chose Azure (https://cloud.netapp.com/blog/azure-cvo-blg-azure-case-studies-with-cloud-volumes-ontap). McKesson needed help to meet the infrastructure needs of their clients (https://cloud.netapp.com/hubfs/success-stories/CS-McKesson.pdf, para. 1).

CDW. (n.d.). *Case study: CDW helps Mid-Cheshire NHS Trust improve patient care by replacing ageing IT infrastructure.* www.uk.cdw.com/about/case-studies/mid-cheshire-nhs-trust

SIXTH EDITION

NURSING INFORMATICS

and the Foundation of Knowledge

Dee McGonigle, PhD, RN, FAAN, ANEF

Director, Virtual Learning Experiences Simulation Excellence (VLESE) in the Center for Transformational Education and Learning Innovation (TELJ), Chamberlain University

Professor, Graduate Program, Chamberlain College of Nursing

Member, Informatics and Technology Expert Panel (ITEP) for the American Academy of Nursing

Kathleen G. Mastrian, PhD, RN

Professor Emerita, Nursing, Pennsylvania State University College of Nursing

Sr. Managing Editor, Online Journal of Nursing Informatics (OJNI)



JONES & BARTLETT
LEARNING



World Headquarters
Jones & Bartlett Learning
25 Mall Road
Burlington, MA 01803
978-443-5000
info@jblearning.com
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Kathy acknowledges the loving support of her family: husband, Chip; children, Ben and Alicia; and sisters, Carol and Sue. She dedicates her work on this edition to her dad, Robert, who died on September 17, 2016, and to her mother, Rosalie Garver, who died on January 29, 2023. Kathy also acknowledges those friends who understand the importance of validation, especially Katie, Lisa, Kathy, Maureen, Anne, Barbara, Roxanne, and Sally.

Preface

The idea for this text originated with the development of nursing informatics (NI) classes, the publication of articles related to technology-based education, and the creation of the *Online Journal of Nursing Informatics (OJNI)*, which Dr. Dee McGonigle cofounded with Dr. Renee Eggers. Like most nurse informaticists, we fell into the specialty; our love affair with technology and gadgets and willingness to be the first to try new things helped to hook us into the specialty of informatics. The rapid evolution of technology and its transformation of the ways of nursing prompted us to try to capture the essence of NI in a text.

As we were developing the first edition, we realized that we could not possibly know all there is to know about informatics and the way in which it supports nursing practice, education, administration, and research. We also knew that our faculty roles constrained our opportunities for exposure to changes in this rapidly evolving field. Therefore, we developed a tentative outline and a working model of the theoretical framework for the text and invited participation from informatics experts and specialists around the world. We were pleased with the enthusiastic responses we received from some of those invited contributors and a few volunteers who heard about the text and asked to participate in their particular area of expertise.

In the second edition, we invited the original contributors to revise and update their chapters. Not everyone chose to participate in the

second edition, so we revised several of the chapters using the original work as a springboard. The revisions to the text were guided by the contributors' growing informatics expertise and the reviews provided by textbook adopters. In the revisions, we sought to do the following:

- Expand the audience focus to include nursing students from bachelor of science (BS) through doctor of nursing practice (DNP) programs as well as nurses thrust into informatics roles in clinical agencies.
- Include, whenever possible, an attention-grabbing case scenario as an introduction or an illustrative case scenario demonstrating why the topic is important.
- Include important research findings related to the topic. Many chapters have research briefs presented in text boxes to encourage the reader to access current research.
- Focus on cutting-edge innovations, meaningful use, and patient safety as appropriate to each topic.
- Include a paragraph describing what the future holds for each topic.

New chapters that were added to the second edition included those focusing on technology and patient safety, system development life cycle, workflow analysis, gaming, simulation, and bioinformatics.

In the third edition, we reviewed and updated all the chapters, reordered some chapters for better content flow, eliminated duplicated content, split the education and research content into two sections, integrated social media content, and added two new chapters: *Data Mining as a Research Tool* and *The Art of Caring in Technology-Laden Environments.*

In the fourth edition, we reviewed and updated all the chapters based on technological advancements and changes to the healthcare arena, including reimbursement mechanisms for services.

In the fifth edition, we added specific information on informatics contributions to quality improvements, interprofessional collaboration, and pandemic response. We pared the fifth edition down to 26 chapters from the previous edition's 29; one chapter each was deleted from Sections II, V, and VII. Section I includes updates to the same five chapters on the building blocks of nursing informatics, with extensive changes to Chapter 3, *Computer Science and the Foundation of Knowledge Model*. To improve flow, we combined content. There was a section describing a virtual reality product with access information for the reader; this product can be accessed in 2D as well as 3D. Chapter 24, *The Art of Caring in Technology-Laden Environments,* was enhanced, and Chapter 25 was replaced with *Our Expanding Realities*.

In this sixth edition, we have once again reviewed and updated all the chapters based on technological advancements and changes to the healthcare arena, including reimbursement mechanisms for services. We have added specific information on informatics contributions to quality improvements and interprofessional collaboration. The section describing a virtual reality product remains, with access information for the reader; this product can be accessed in 2D as well as 3D. This edition has been decreased to 25 chapters. Chapter 24. *Bioinformatics, Biomedical Informatics, and Computational Biology*, was eliminated by integrating this content appropriately throughout the textbook.

The major revisions follow:

Chapter 1 was enhanced by exploring the impacts of AI, cognitive systems, machine learning and predictive analytics on knowledge management in organizations, the importance of knowledge co-creation, and the characteristics of knowledge work.

Chapter 2 emphasizes the need to ethically implement ISs to mitigate impacts on users and institutions, discusses the issues associated with asset classification (i.e., drug or device), and explores issues related to IoT (Intelligence of Things; Internet of Things) and AIoT (Artificial Intelligence of Things).

Chapter 3 was heavily revised and shortened. Tables were created for computer components, summarizing major types of software and

input devices. The following were added: haptics for immersive technologies and VR (Virtual Reality), VPN (Virtual Private Network) with encryption, and the introduction of the concept of the metaverse.

Chapter 4 explores AI (Artificial Intelligence), machine learning, and natural language processing.

Chapter 5 discusses the ethics of using robots as substitutes for human carers, identifies challenges and opportunities related to social media use by patients and providers, and discusses motives for seeking information and emotional support online.

Chapter 6 explores the evolution of NI definitions and shares the current NI definition. It also updates AACN education guidelines and shares 2021 informatics competencies identified in *Essentials: Core Competencies for Professional Nursing Education*.

Chapter 7 shares updates from the third edition of the ANA's *Nursing Informatics: Scope and Standards of Practice* (2022), presents ways in which INSs (Informatics Nurse Specialist) provide value, and explores trends influencing the future of NI (Nursing Informatics).

Chapter 8 was updated to reflect the concerns related to the use of personal devices in the workplace and BYOD policies, notes that CMPs (Civil Monetary Penalties) associated with PHI (Protected Health Information) breaches may increase with inflation, alerts that Privacy Rule changes are expected in mid-2023, and provides access to the global health legislation tracker.

Chapter 9 updates the description of object-oriented modeling, CASE (Computer-aided Software Engineering), and differentiates between free software and open source software.

Chapter 10 expands the discussion of interoperability and the use of metadata tagging in the interoperability context, discusses documentation integrity, introduces and defines unified communication for health care, updates ADT (Admission, Discharge, and Transfer System) description and use, and introduces CDI (Clinical Documentation Improvement).

Chapter 11 explores data visualization as a tool to model complex healthcare data and clarifies NFC (Near-field Communication)

transactions. Also added is a detailed description of VR headset use and a discussion of the importance of managing HTI (Human-Technology Interaction) with new technologies.

Chapter 12 provides updated tips for creating strong passwords, expands the discussion of electronic data vulnerability, and reviews recent data breaches.

Chapter 13 emphasizes the value of process improvement theories, introduces the Patient Room 'Next' (PRN) strategy for providing high-quality healthcare regardless of patient location, and reviews the seven key steps for a quality improvement project.

Chapter 14 updates EHR (Electronic Health Record) adoption statistics and explores how interoperable EHRs facilitate data sharing.

Chapter 15 shares 10 common medical errors leading to patient deaths and access to global strategies for safety. It also explores the contributions of wearable technologies to safety and early detection of issues.

Chapter 16 shares changes in the fitness app market, explores the use of an AI-powered web-based symptom checker and medical misinformation during the pandemic, discusses the digital divide via an interactive map tool, identifies wearable technology as consumer-centric technology, and introduces virtual and augmented reality tools for engagement.

Chapter 17 describes the EPA (Environmental Protection Agency) risk assessment, introduces AI as a prediction tool for disease outbreaks, and explores quality public health messaging.

Chapter 18 provides updated healthcare spending costs. It offers a definition and explains its use to help reduce disparities. It also explores medical and nurse licensure compacts as well as telehealth support and regulations changes post-pandemic.

Chapter 19 acknowledges the pandemic's impact on telecommunications, virtual technology use, and the paradigm shift with the shutdowns. It reviews clinical replacement and augmentation with simulation, explains how adaptive learning is integrated into LMS (Learning Management System), and provides updates on Gen Z, AI, and the learning disruption caused by

ChatGPT. It also provides an actual, unedited interaction with ChatGPT about AI and explores some faculty's reactions to ChatGPT or other AI products students are using.

Chapter 20 acknowledges the role of the pandemic in the escalated integration of virtual simulation and explores a new initiative at a children's hospital with VR on every unit.

Chapter 21 identifies the information literacy competency standards specific to nursing and acknowledges the role of the pandemic in accelerating the commitment to collecting healthcare data in a standardized way to facilitate data sharing and treatment outcomes.

Chapter 22 expands the former data mining chapter to include artificial intelligence, bioinformatics, and computational biology contributions to data analytics. It acknowledges the contributions of the former BD2K (Big Data to Knowledge) program, advocates for the use of EHR data for comparative effectiveness research, and identifies three main types of data analytics. Finally, this chapter incorporates information from the former Chapter 24 from the fifth edition on bioinformatics and computational biology and their contributions to data analysis.

Chapter 23 explores the potential contributions of bioinformatics and computational biology to evidence for practice, introduces the NCATS (National Center for Advancing Translational Sciences) translational science spectrum, and incorporates information from the former Chapter 24 from the fifth edition on bioinformatics and computational biology and their effects on clinical translation

Chapter 24 advocates for adding technology as a fifth dimension of the nursing paradigm, considerations for conveying caring while wearing PPE (Personal Protective Equipment), and caring encounters as communion-in-caring. It also emphasizes reflection to improve caring encounters.

Chapter 25 examines the emerging technologies evolving our sense of reality that will affect the future of health care, nursing practice, nursing informatics, and patient care. To help the reader consider the disruptive forces affecting our realities, we have provided a glimpse of patient experiences in future health care, care

bots, cyborgs, and artificial intelligence. Through our use of nursing informatics in the integration of evolving technologies, we affect our reality, the reality of the healthcare industry, the reality of our patients, and the reality of the concept of the metaverse, and all of these concepts are explored in this chapter. In addition, the chapter explores haptic technology and its future in nursing, encourages the reader to think about the impact AI will have on our reality, and includes a new section on the metaverse in which the following topics are discussed:

- Complex definition of the metaverse is provided and then a simplified one
- ChatGPT interaction: describe the concept of a metaverse to a nursing student
- The promise of the metaverse
- Four facets
- Three components
- Use cases: how the metaverse is impacting and will impact healthcare
- Challenges facing the realization of the metaverse
- Nursing role-specific challenges

In addition, the ancillary materials have been updated and enhanced to include competency-based self-assessments, mapping the content to the current NI standards, activities for both undergraduate and graduate nursing students, and 10 interactive case studies.

We believe that this text provides a comprehensive elucidation of this exciting field. Its theoretical underpinning is the Foundation of Knowledge model. This model is introduced in its entirety in the first chapter, which discusses nursing science and its relationship to NI. We believe that humans are organic information systems that are constantly acquiring, processing, and generating information or knowledge in both their professional and their personal lives. It is

their high degree of knowledge that characterizes humans as extremely intelligent, organic machines. Individuals have the ability to manage knowledge—an ability that is learned and honed from birth. We make our way through life interacting with our environment and being inundated with information and knowledge. We experience our environment and learn by acquiring, processing, generating, and disseminating knowledge. As we interact in our environment, we acquire knowledge that we must process. This processing effort causes us to redefine and restructure our knowledge base and generate new knowledge. We then share (disseminate) this new knowledge and receive feedback from others. The dissemination and feedback initiate this cycle of knowledge over again, as we acquire, process, generate, and disseminate the knowledge gained from sharing and reexploring our own knowledge base. As others respond to our knowledge dissemination and we acquire new knowledge, we engage in rethinking and reflecting on our knowledge, processing, generating, and then disseminating anew.

The purpose of this text is to provide a set of practical and powerful tools to ensure that the reader gains an understanding of NI and moves from information through knowledge to wisdom. Defining the demands of nurses and providing tools to help them survive and succeed in the Knowledge Age remains a major challenge. Exposing nursing students and nurses to the principles and tools used in NI helps to prepare them to meet the challenge of practicing nursing in the Knowledge Age while striving to improve patient care at all levels.

The text provides a comprehensive framework that embraces knowledge so that readers can develop their knowledge repositories and the wisdom necessary to act on and apply that knowledge. The text is divided into seven sections.

- Section I, *Building Blocks of Nursing Informatics*, covers the building blocks of NI: nursing science, information science, computer science, cognitive science, and the ethical management of information.

- Section II, *Perspectives on Nursing Informatics*, provides readers with a look at various viewpoints on NI and NI practice as described by experts in the field.
- Section III, *Nursing Informatics Administrative Applications: Precare and Care Support*, covers important functions of administrative applications of NI.
- Section IV, *Nursing Informatics Practice Applications: Care Delivery*, covers healthcare delivery applications, including electronic health records (EHRs), clinical information systems, telehealth, patient safety, patient and community education, and care management.
- Section V, *Education Applications of Nursing Informatics*, presents subject matter on how informatics supports nursing education.
- Section VI, *Research Applications of Nursing Informatics*, covers informatics tools to support nursing research, including data mining and bioinformatics.
- Section VII, *Imagining the Future of Nursing Informatics*, focuses on the future of NI, emphasizes the need to preserve caring functions in technology-laden environments, and explores our expanding realities and the metaverse.

The introduction to each section explains the relationship between the content of that section and the Foundation of Knowledge model. This text places the material within the context of knowledge acquisition, processing, generation, and dissemination. It serves both nursing students (BS to DNP/PhD) and professionals who need to understand, use, and evaluate NI knowledge. As nursing professors, our major responsibility is to prepare the practitioners and leaders in the field. Because NI permeates the entire scope of nursing (i.e., practice, administration, education, and research), nursing education curricula must include NI. Our primary objective is to develop the most comprehensive and user-friendly NI text on the market to prepare nurses for current and future practice challenges.

In particular, this text provides a solid groundwork from which to integrate NI into practice, education, administration, and research.

The goals of this text are as follows:

- Impart core NI principles that should be familiar to every nurse and nursing student.
- Challenge novices to experts concerning NI's competencies and impact on every area of nursing practice.
- Help the reader understand knowledge and how it is acquired, processed, generated, and disseminated.
- Explore the changing role of NI professionals.
- Demonstrate the value of the NI discipline as an attractive field of specialization.
- Challenge the reader to expand personal horizons to embrace emerging technologies and new realities.

Meeting these goals will help nurses and nursing students understand and use fundamental NI principles so that they efficiently and effectively function as current and future nursing professionals to enhance the nursing profession and improve the quality of health care. The authors would also like to challenge nursing informatics experts to continually expand their horizons and passion for appropriate integration of technology in all facets of nursing care. The overall vision, framework, and pedagogy of this text offer benefits to readers by highlighting established principles while drawing out new ones that continue to emerge as nursing and technology evolve.

Authors' Note

This text provides an overview of nursing informatics from the perspective of diverse experts in the field, as well as current and seminal research and literature, with a focus on nursing informatics and the Foundation of Knowledge model. We want our readers and students to focus on the relationship of knowledge to informatics and to embrace and maintain the caring functions of nursing—messages all too often lost in the romance with technology. We hope you enjoy the text!

Contributors

Ida Androwich, PhD, RN, BC, FAAN
Loyola University Chicago
School of Nursing
Maywood, IL

Steven Brewer, PhD
Assistant Professor, Criminal Justice
East Carolina University
Greenville, NC

Nicholas Hardiker, PhD, RN
Senior Research Fellow
University of Salford
School of Nursing & Midwifery
Salford, UK

Glenn Johnson, MLS
Pennsylvania State University
University Park, PA

Julie Kenney, MSN, RNC-OB
Clinical Analyst
Advocate Health Care
Oak Brook, IL

Craig McGonigle, MBA, BSB, CGA
Virtual Immersive Simulation Solutions Architect

Whitemouse Productions, UK
Auburndale, FL

Jackie Ritzko
Pennsylvania State University
Hazelton, PA

Jeff Swain
Instructional Designer
Pennsylvania State University
University Park, PA

Denise D. Tyler, MSN/MBA, RN-BC
Implementation Specialist
Healthcare Provider, Consulting
ACS, a Xerox Company
Dearborn, MI

The editors wish to acknowledge the work of the following first edition contributors (original contributions were updated by McGonigle and Mastrian for the second through the sixth editions):

Kathleen Albright, BA, RN
Strategic Account Manager
GE Healthcare
Philadelphia, PA

Emily Barey, MSN, RN
Director of Nursing Informatics
Epic Systems Corporation
Madison, WI

Lisa Reeves Bertin, BS, EMBA
Pennsylvania State University
Sharon, PA

Brett Bixler, PhD
Pennsylvania State University
University Park, PA

Jennifer Bredemeyer, RN
Loyola University Chicago
School of Nursing
Skokie, IL

Jon Brouchoud
CEO, Arch Virtual, Developers of Acadicus
Madison, WI

Sylvia M. DeSantis, MA
Pennsylvania State University
University Park, PA

Judith Effken, PhD, RN, FACMI
University of Arizona
College of Nursing
Tucson, AZ

Nedra Farcus, MSN, RN
Retired from Pennsylvania State University, Altoona
Altoona, PA

Kathleen M. Gialanella, JD, RN, LLM
Law Offices
Westfield, NJ
Associate Adjunct Professor
Teachers College, Columbia University
New York, NY
Adjunct Professor
Seton Hall University, College of Nursing & School of Law
South Orange & Newark, NJ

Denise Hammel-Jones, MSN, RN-BC, CLSSBB
Greencastle Associates Consulting
Malvern, PA

Schuyler F. Hoss, BA
Northwest Healthcare Management
Vancouver, WA

June Kaminski, MSN, RN
Kwantlen University College

Surrey, British Columbia, Canada

Audrey Kinsella, MA, MS
Information for Tomorrow
Telehealth Planning Services
Asheville, NC

Margaret Ross Kraft, PhD, RN
Loyola University Chicago
School of Nursing
Maywood, IL

Wendy L. Mahan, PhD, CRC, LPC
Pennsylvania State University
University Park, PA

Heather McKinney, PhD
Pennsylvania State University
University Park, PA

Nickolaus Miehl, MSN, RN
Oregon Health Sciences University
Monmouth, OR

Peter J. Murray, PhD, RN, FBCS
Coachman's Cottage
Nocton, Lincoln, UK

Lynn M. Nagle, PhD, RN
Assistant Professor
University of Toronto

Susan M. Paschke, MSN, RN
The Cleveland Clinic
Cleveland, OH

Sheldon Prial, RPH, BS Pharmacy
Sheldon Prial Consulting
Melbourne, FL

Nancy Staggers, PhD, RN, FAAN
Professor, Informatics
University of Maryland

Baltimore, MD

Marianela Zytkowsi, MSN, RN
The Cleveland Clinic
Cleveland, OH



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SECTION I
Building Blocks of Nursing Informatics

Chapter 1 Nursing Science and Concepts of Knowledge

Chapter 2 Introduction to Information, Information Science, and Information Systems

Chapter 3 Computer Science and the Foundation of Knowledge Model

Chapter 4 Introduction to Cognitive Science and Cognitive Informatics

Chapter 5 Ethical Applications of Informatics

Nursing professionals are information-dependent knowledge workers. As health care continues to evolve as a data-driven and information-dependent enterprise, professionals—that is, the knowledge workers—must be well prepared to make significant contributions by harnessing informatics concepts and tools. Nursing informatics (NI), a product of the scientific synthesis of information in nursing, encompasses concepts from computer science, cognitive science, information science, and nursing science. NI continues to evolve as more and more professionals access, use, and develop the information, computer, and cognitive sciences necessary to advance nursing science for the betterment of patients and the profession. Regardless of their future roles in the healthcare milieu, it is clear that nurses need to understand the ethical application of information, computer, and cognitive sciences to advance nursing science and build the nursing knowledge base.

To implement NI, one must view it from the perspective of both the current healthcare delivery system and the specific, individual organizational needs while anticipating and creating future applications in both the healthcare system and the nursing

profession. Nursing professionals should be expected to discover opportunities to use NI; participate in the design of solutions; and be challenged to identify, develop, evaluate, modify, and enhance applications to improve patient care. This text is designed to provide the reader with the information and knowledge needed to meet this expectation.

Section I presents an overview of the building blocks of NI: the nursing, information, computer, and cognitive sciences. Also included in this section is a chapter on ethical applications of NI. This section is central to understanding the content in subsequent chapters.

Chapter 1, *Nursing Science and Concepts of Knowledge*, describes nursing science, explores concepts of knowledge and knowledge development, and introduces the Foundation of Knowledge model as the conceptual framework for the book. In this chapter, a clinical case scenario is used to illustrate the knowledge concepts central to nursing science and practice. A definition of nursing science is derived here from the American Nurses Association's definition of nursing. Nursing science is the ethical application of knowledge acquired through education, research, and practice to provide services and interventions to patients to maintain, enhance, or restore their health and to acquire, process, generate, and disseminate nursing knowledge to advance the nursing profession. Knowledge derived from information is a concept central to nursing, and knowledge is health care's most valuable resource. Informatics technologies support individual and organizational knowledge management. Information science and systems, together with computers and other technologies, are constantly changing the way that professionals practice and healthcare organizations conduct their business, which will continue to evolve.

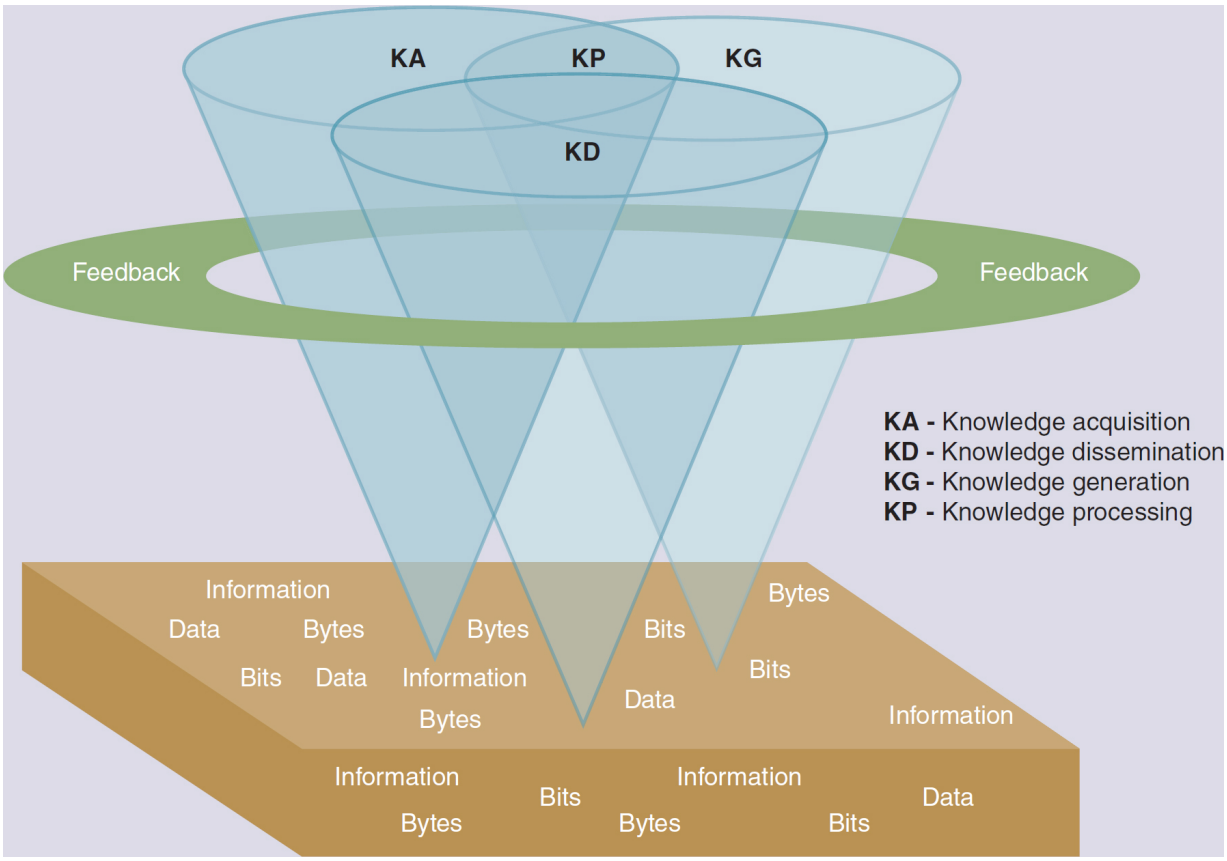
To prepare for these innovations, the reader must understand fundamental information and computer concepts, covered in Chapters 2 and 3, *Introduction to Information, Information Science, and Information Systems* and *Computer Science and the Foundation*

of Knowledge Model, respectively. Information science deals with the interchange (or flow) and scaffolding (or structure) of information and involves the application of information tools for solutions to patient care and business problems in health care. To be able to use and synthesize information effectively, an individual must be able to obtain, perceive, process, synthesize, comprehend, convey, and manage the information. Computer science deals with understanding the development, design, structure, and relationship of computer hardware and software. This science offers extremely valuable tools that, if used skillfully, can facilitate the acquisition and manipulation of data and information by nurses who can then synthesize these resources into an ever-evolving knowledge and wisdom base. This synthesis not only facilitates professional development and the ability to apply evidence-based practice decisions within nursing care, but if these resources are disseminated and shared, it can also advance the nursing science knowledge base. The development of knowledge tools, such as the automation of decision-making and the strides being made in artificial intelligence, has altered the understanding of knowledge and its representation. The ability to structure knowledge electronically facilitates the ability to share knowledge structures and enhance collective knowledge.

As discussed in Chapter 4, *Introduction to Cognitive Science and Cognitive Informatics,* cognitive science deals with how the human mind functions. This science encompasses how people think, understand, remember, synthesize, and access stored information and knowledge. The nature of knowledge, including how it is developed, used, modified, and shared, provides the basis for continued learning and intellectual growth. Cognitive science principles underpin computer and software development as well as more advanced informatics topics such as artificial intelligence (AI) and robotics. Chapter 5, *Ethical Applications of Informatics*, focuses on ethical issues associated with managing private information with technology and provides a framework for analyzing ethical issues and supporting ethical decision-making. This chapter provides working wisdom by allowing the reader to experience an expert's

practical application of knowledge and experience as they address specific situations; it walks the reader through an expert's application of the ETHICAL model.

The material in this book is placed within the context of the Foundation of Knowledge model (shown in **Figure I-1**, which is more fully introduced and explained in Chapter 1, *Nursing Science and Concepts of Knowledge*). The Foundation of Knowledge model is used throughout the text to illustrate how knowledge is used to meet the needs of healthcare delivery systems, organizations, patients, and nurses. Through interaction with the building blocks of knowledge—the theories, architecture, and tools—one acquires the bits and pieces of data necessary to synthesize them into information and then generate and disseminate the resulting knowledge. Through this dynamic exchange, which includes feedback, individuals continue the interaction with and use of these sciences to input, or acquire; process; and output, or disseminate, generated knowledge. Humans experience their environment and learn by acquiring, processing, generating, and disseminating knowledge. When they then share (disseminate) this new knowledge and receive feedback on the knowledge they have shared, the feedback initiates the cycle of knowledge all over again. As individuals acquire, process, generate, and disseminate knowledge, they are motivated to share, rethink, reflect on, and explore their own knowledge base. This complex process is captured in the Foundation of Knowledge model. Throughout the chapters in Section I, *Building Blocks of Nursing Informatics*, readers are challenged to think about how the model can help them to understand the ways in which they acquire, process, generate, disseminate, and then receive and process feedback on their new knowledge of the building blocks of NI.



Designed by Alicia Mastrian

Figure I-1 Foundation of Knowledge Model

Description



CHAPTER 1

Nursing Science and Concepts of Knowledge

OBJECTIVES

1. Define nursing science and its relationship to nursing informatics.
2. Introduce the Foundation of Knowledge model as the organizing conceptual framework for the text.
3. Explore the complex relationships among nursing informatics principles, concepts of knowledge, and knowledge co-creation.

KEY TERMS

- borrowed theory
- building block
- clinical database
- clinical practice guideline
- conceptual framework
- data
- data mining
- evidence
- feedback
- Foundation of Knowledge model
- information
- knowledge
- knowledge acquisition
- knowledge dissemination

- knowledge domain process (KDP) model
- knowledge generation
- knowledge management system (KMS)
- knowledge processing
- knowledge worker
- nursing informatics (NI)
- nursing science
- nursing theory
- relational database
- transparent wisdom

Introduction

Nursing informatics (NI) has been traditionally defined as a specialty that integrates **nursing science**, computer science, and information science to manage and communicate **data**, **information**, knowledge, and wisdom in nursing practice. This chapter focuses on nursing science as one of the **building blocks** of NI. As depicted in **Figure 1-1**, the traditional definition of NI is extended in this text to include cognitive science. The Foundation of Knowledge model is also introduced as the organizing **conceptual framework** of this text, and the model is tied to nursing science and the practice of NI. We conclude the chapter with an overview of key knowledge concepts and establish that nurses are knowledge workers.

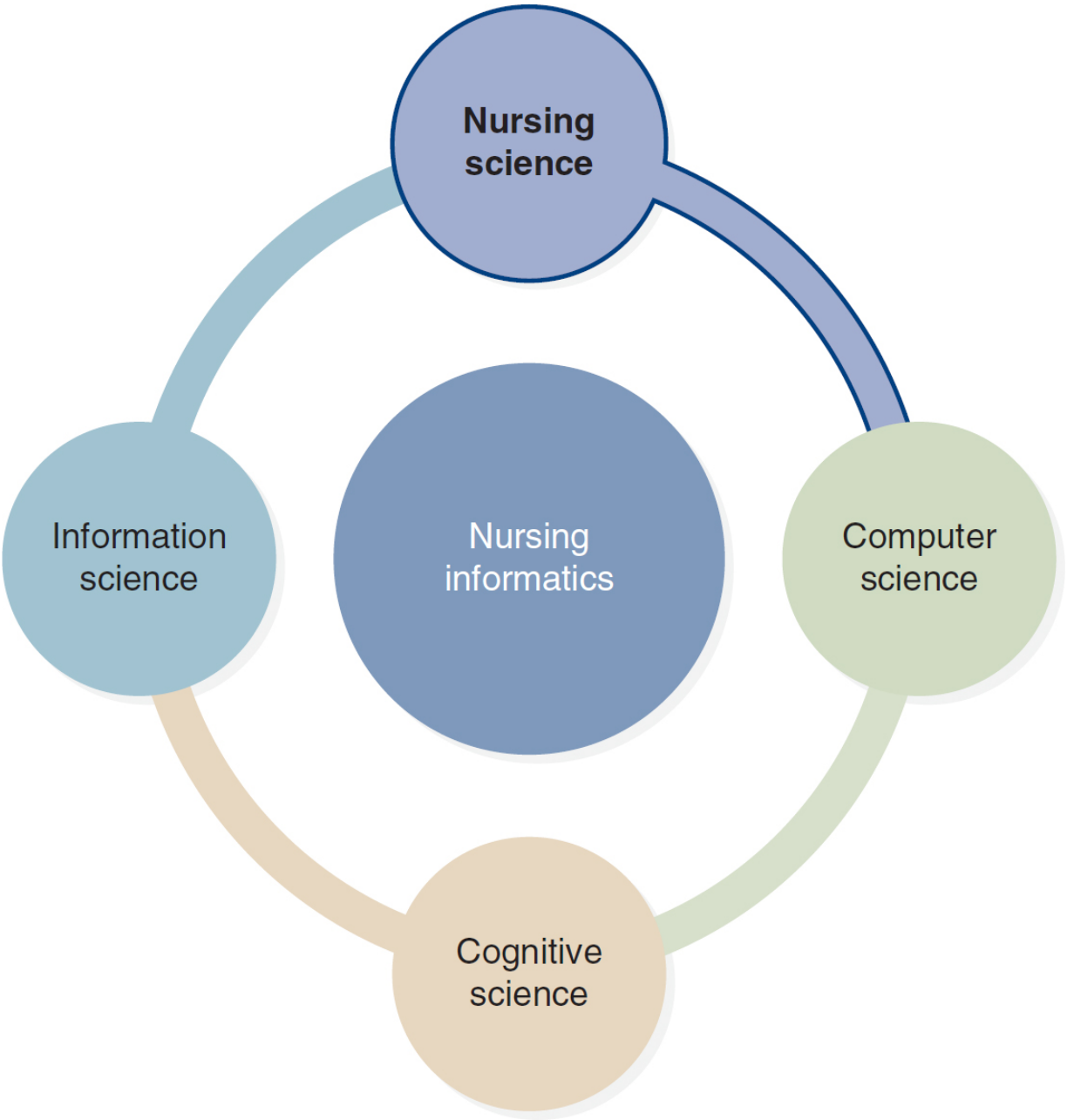


Figure 1-1 Building Blocks of Nursing Informatics

Nursing Science

Consider the following patient care scenario as a basis for understanding nursing science:

> *Tom H. is a registered nurse in a busy metropolitan hospital emergency room. He has just admitted a 79-year-old man whose wife brought him to the hospital because he is having trouble breathing. Tom immediately clips a pulse oximeter to the patient's finger and quickly assesses the patient's other vital signs. He discovers a rapid pulse rate and a decreased oxygen saturation level in addition to rapid and labored breathing. Tom determines that the patient is not in immediate danger and that he does not require intubation. Tom focuses his initial attention on easing the patient's labored breathing by elevating the head of the bed and initiating oxygen treatment; he then hooks the patient up to a heart monitor. Tom continues to assess the patient's breathing status as he performs a head-to-toe assessment of the patient that leads to the nursing diagnoses and additional interventions necessary to provide comprehensive care to this patient.*

Consider Tom's actions and how and why he intervened as he did. Tom relied on the immediate data and information that he acquired during his initial rapid assessment to deliver appropriate care to his patient. Tom also used technology (a pulse oximeter and a heart monitor) to assist with and support the delivery of care. What is not immediately apparent, and some would argue is transparent (done without conscious thought), is the fact that during the rapid assessment, Tom reached into his knowledge base of previous learning and experiences to direct his care so that he could act with **transparent wisdom**. He used both **nursing theory** and **borrowed theory** to inform his practice. Tom certainly used the nursing process theory, and he may have also used one of several other nursing theories, such as Rogers's science of unitary human beings, Orem's theory of self-care deficit, or Roy's adaptation theory. In addition, Tom may have applied his knowledge from some of the basic sciences, such as anatomy, physiology, psychology, and chemistry, as he determined the patient's immediate needs.

Information from Maslow's hierarchy of needs, Lazarus's transaction model of stress and coping, and the health belief model may have also helped Tom practice professional nursing. He gathered data and then analyzed and interpreted those data to form a conclusion—the essence of science. Tom illustrates the practical aspects of nursing science.

The focus of nursing is on human responses to actual or potential health problems and advocacy for various clients. These human responses are varied and may change over time in a single case. Nurses must possess the technical skills to manage equipment and perform procedures; the interpersonal skills to interact appropriately with people; and the cognitive skills to observe, recognize, collect, analyze, and interpret data to reach a reasonable conclusion, which forms the basis of a decision. At the heart of each of these skills lies the management of data and information. Nursing science focuses on the ethical application of knowledge acquired through education, research, and practice to provide services and interventions to patients to maintain, enhance, or restore their health and to acquire, process, generate, and disseminate nursing knowledge to advance the nursing profession.

Nursing is an information-intensive profession. The steps of using information, applying knowledge to a problem, and acting with wisdom form the basis of nursing science practice. Information is composed of data that were processed using knowledge. For information to be valuable, it must be accessible, accurate, timely, complete, cost-effective, flexible, reliable, relevant, simple, verifiable, and secure. **Knowledge** is the awareness and understanding of a set of information and ways that this information can be made useful to support a specific task or arrive at a decision. In the case scenario, Tom used accessible, accurate, timely, relevant, and verifiable data and information. He compared that data and information to his knowledge base of previous experiences to determine which data and information were relevant to the current case. By applying his previous knowledge to data, he converted those data into information and information into new knowledge—that is, an understanding of which nursing interventions were

appropriate in this case. Thus, information is data made functional through the application of knowledge.

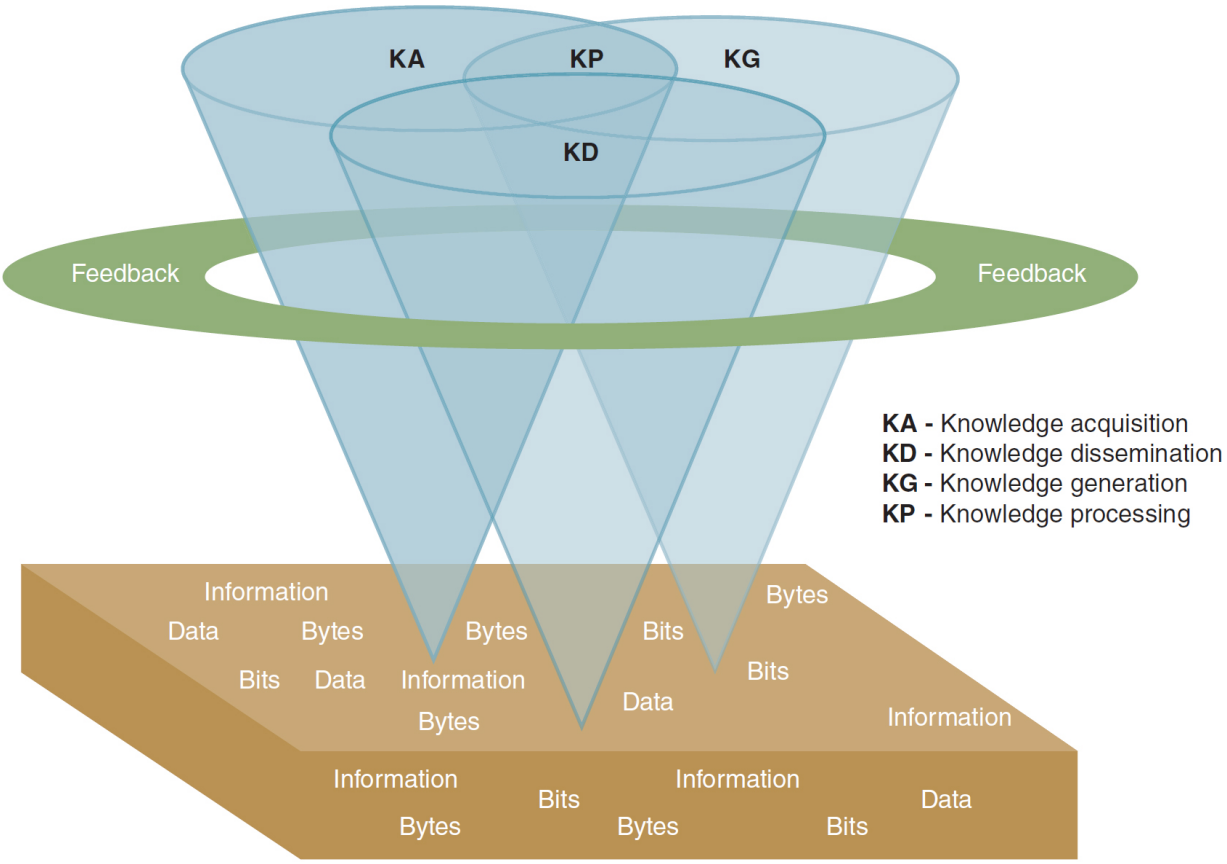
Humans acquire data and information in bits and pieces and then transform the information into knowledge. The information-processing functions of the brain are frequently compared to those of a computer and vice versa. (See a discussion of cognitive informatics in Chapter 4, *Introduction to Cognitive Science and Cognitive Informatics*, for more information.) Humans can be thought of as organic information systems that are constantly acquiring, processing, and generating information or knowledge in their professional and personal lives. They have an amazing ability to manage knowledge. This ability is learned and honed from birth as individuals make their way through life interacting with the environment and being inundated with data and information. Each person experiences the environment and learns by acquiring, processing, generating, and disseminating knowledge.

Tom, for example, acquired knowledge in his basic nursing education program and continues to build his foundation of knowledge by engaging in such activities as reading nursing research and theory articles, attending continuing education programs, consulting with expert colleagues, and using **clinical databases** and **clinical practice guidelines**. As he interacts in the environment, he acquires data that must be processed into knowledge. This processing effort causes him to redefine and restructure his knowledge base and generate new knowledge. Tom can then share (disseminate) this new knowledge with colleagues, and he may receive **feedback** on the knowledge that he shares. This dissemination and feedback build the knowledge foundation anew as Tom acquires, processes, generates, and disseminates new knowledge as a result of his interactions. As others respond to his knowledge dissemination and he acquires yet more knowledge, he is engaged to rethink, reflect on, and reexplore his knowledge acquisition, leading to further processing, generating, and then disseminating knowledge. It should be clear at this point that knowledge management is a fundamental part of nursing science.

What will become even clearer as the text unfolds is how informatics supports knowledge management.

Foundation of Knowledge Model

We developed the **Foundation of Knowledge model** to illustrate these ongoing knowledge processes. The model (**Figure 1-2**) is used as an organizing framework for this text and as a way to help the reader focus on how we develop and use an individual knowledge base.



Designed by Alicia Mastrian

Figure 1-2 Foundation of Knowledge Model

Description

At its base, the model contains bits, bytes (computer terms used to quantify data), data, and information in a random representation. Growing out of the base are separate cones of light that expand as they reflect upward; these cones represent **knowledge acquisition**, **knowledge generation**, and **knowledge dissemination**. At the intersection of the cones and forming a new cone is **knowledge processing**. Encircling and cutting through the knowledge cones is feedback, which acts on and may transform any or all aspects of knowledge represented by the cones. One should imagine the model as a dynamic figure in which the cones of light and the feedback rotate and interact rather than remaining static. Knowledge acquisition, knowledge generation, knowledge dissemination, knowledge processing, and feedback are constantly evolving for nursing professionals. The transparent effect of the cones is deliberate and intended to suggest that as knowledge grows and expands, its use becomes more transparent, meaning people use this knowledge during practice without even being consciously aware of which aspect of knowledge they are using at any given moment.

To simplify the understanding of the Foundation of Knowledge model, it may be helpful to think back on an early learning experience. Recall the first time you got behind the wheel of a car. There was so much to remember to do and so much to pay attention to, especially if you wanted to avoid an accident. You had to think about how to start the car, adjust the mirrors, fasten the seat belt, and shift the car into gear. You had to take in data and information from friends and family members who tried to "tell" you how to drive. They disseminated knowledge, and you acquired it. And they most likely provided lots of feedback about your driving. As you drove down the street, you also had to notice multiple bits of data in the environment, such as stop signs, traffic signals, turn signals, and speed limit signs, and try to interpret these environmental data into usable information for the current situation. You had to pay attention to several things simultaneously to drive safely. As your confidence grew with experience, you were able to drive more effectively and generate new knowledge about driving that became part of your

personal knowledge structure. After many driving experiences, the process of driving became transparent and seamless. Think about this example in relation to a skill that you have acquired or are acquiring in your nursing education. How does or did your learning experience mirror the components of the Foundation of Knowledge model? Experienced nurses, thinking back to their novice years, may recall feeling like their heads were filled with bits of data and information that did not form any type of cohesive whole. As the model depicts, the processing of knowledge begins a bit later (imagine a timeline applied vertically, with early experiences on the bottom and expertise growing as the processing of knowledge ensues). Early on in nurses' education, conscious attention is focused mainly on knowledge acquisition, and beginning nurses depend on their instructors and others to process, generate, and disseminate knowledge. As nurses become more comfortable with the science of nursing, they begin to independently perform some of the other Foundation of Knowledge functions. However, to keep up with the explosion of information in nursing and health care, they must continue to rely on the knowledge generation of nursing theorists and researchers and the dissemination of their work. In this sense, nurses are committed to lifelong learning and the use of knowledge in the practice of nursing science.

Knowledge management and transfer in healthcare organizations are likely to be studied in greater depth as our understanding of professional knowledge increases and our processes to capture and codify it improve. We must strive to facilitate the data, information, and knowledge exchange in the right format between the right people when they need it to proficiently create value for and add value to the organization (APQC, 2022). The Foundation of Knowledge model is not perfect, and others have developed models of knowledge that are more complex. For example, Evans and Alleyne (2009) constructed the **knowledge domain process (KDP) model** to represent knowledge construction and dissemination in an organization. Yet they caution as follows:

> *[T]he KDP model, like all models, is an abstraction aimed at making complex systems more easily understood. While the model presents knowledge processes in a structured and simplified form, the nature and structure of the processes themselves may be open to debate.* (p. 148)

As we will learn later in this chapter, getting the knowledge to the user and creating a culture where new knowledge is seamlessly integrated into health care remain a challenge. Mason (2020) offered this insight:

> *Simply put, knowledge management undertakes to identify what is in essence a human asset buried in the minds and hard drives of individuals working in an organization. Knowledge management also requires a system that will allow the creation of new knowledge, a dissemination system that will reach every employee, with the ability to package knowledge as value-added in products, services and systems.* (para. 1)

Other impacts that currently challenge knowledge management and will become necessary to synthesize into a comprehensive knowledge management process are the technologies advancing cognitive computing, artificial intelligence (AI), cognitive systems, machine learning, and predictive analytics. These ongoing advancements will "radically transform how we learn and interact in the digital world" and within our organizations (APQC, 2022, para. 18). **Figure 1-3** depicts the life cycle of knowledge management in an organization. Note the informatics tools that are integral to knowledge management, particularly in its knowledge dissemination, knowledge development, and knowledge processing aspects.

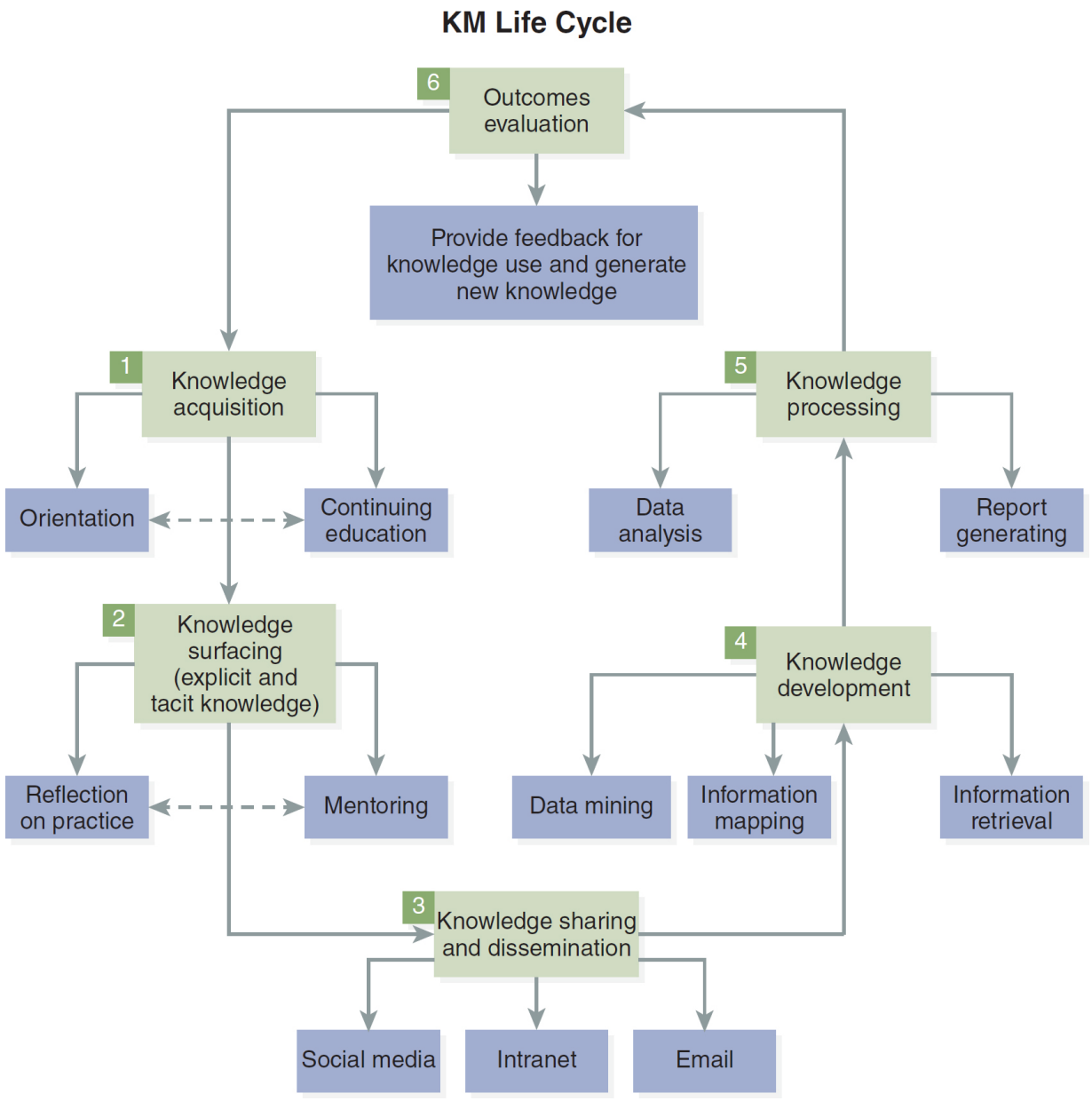


Figure 1-3 The Knowledge Management Life Cycle

Description

For nurse knowledge workers, information is their primary resource, and when they deal with information, they do so in overlapping phases. That is, the nurses are continually acquiring, processing, assimilating, retaining, and using this information to generate and disseminate knowledge. However, the phases are not sequential; instead, a constant gleaning of data and information

from the environment takes place, with the data and information massaged into knowledge bases so that knowledge can be applied and shared (disseminated).

The Foundation of Knowledge model permeates this text, reflecting the understanding that knowledge is a powerful tool and that nurses focus on information as a key building block of knowledge. The application of the model is described to help the reader understand and appreciate the foundation of knowledge in nursing science and see how it applies to NI. All the nursing roles (i.e., practice, administration, education, research, and informatics) involve the science of nursing. Nurses are **knowledge workers**, working with and generating information and knowledge as a product. They are knowledge acquirers, providing convenient and efficient means of capturing and storing knowledge. They are knowledge users, meaning individuals or groups that benefit from valuable, viable knowledge. Nurses are knowledge engineers, people who design, develop, implement, and maintain knowledge. They are knowledge managers by capturing and processing collective expertise and distributing it where it can create the greatest benefit. Finally, they are knowledge developers and generators, people who change and evolve knowledge based on the tasks at hand and the information available. McGowan et al. (2018) described a similar model, the Knowledge Worker Knowledge Enhancement Process, a process whereby knowledge workers actively seek, apply, embed, and share newly acquired knowledge with others. Knowledge workers "apply their mental competencies" (MasterClass, 2022, para. 1).

More recently introduced in popular literature was the concept of a "learning worker," one who has the ability to learn quickly and continuously (Salisbury, 2017) and "extract the learning from their work experiences" (Euro Digital Systems, 2021, para. 25), a designation that is not as frequently seen in the popular literature as the term *knowledge worker* even though many healthcare organizations are transitioning to learning organizations.

In the case scenario, at first glance one might label Tom as a knowledge worker, acquirer, and user. However, stopping there might

sell Tom short in his practice of nursing science. Although he acquired and used knowledge to help him achieve his work, he also processed the data and information he collected to develop a nursing diagnosis and a plan of care. The knowledge stores Tom used to develop and glean knowledge from valuable information are generative (having the ability to originate and produce, or generate). For example, Tom may have learned something new about his patient's culture from the patient or his wife, which he will keep by filing it in the knowledge repository of his mind to be used in a similar situation. As he compares this new cultural information to what he already knows, he may gain insight into the effect of culture on a patient's response to illness. In this sense, Tom is a knowledge generator. If he shares this newly acquired knowledge with another practitioner as he records his observations and conclusions, he is then disseminating knowledge. Tom also uses feedback from the various technologies he has applied to monitor his patient's status. In addition, he may rely on feedback from laboratory reports or even other practitioners to help him rethink, revise, and apply the knowledge that he is generating about this patient.

To have ongoing value, knowledge must be viable. Knowledge viability refers to applications (most of them technology based) that offer easily accessible, accurate, and timely information obtained from a variety of resources and methods and presented in a manner so as to provide the necessary elements to generate new knowledge. In the case scenario, Tom may have felt the need to consult an electronic database or a clinical guidelines repository that he has downloaded on his tablet or smartphone or that resides in the emergency room's networked computer system to assist him in the development of a comprehensive care plan for his patient. In this way, Tom uses technology and **evidence** to support and inform his practice. It is also possible in this scenario that an alert might appear in the patient's electronic health record or in the clinical information system to remind Tom to ask about influenza and pneumonia vaccines. Clinical information technologies that support and inform nursing practice and nursing administration are an important part of NI.

The Nature of Knowledge

Knowledge may be thought of as either explicit or tacit. Explicit knowledge is the knowledge that one can convey in letters, words, and numbers. It can be exchanged or shared in the form of data, manuals, product specifications, principles, policies, and theories. Nurses can disseminate and share this knowledge publicly, or on the record, and scientifically, or methodically. A nursing model or theory that is well developed and easily explained and understood is an example of explicit knowledge. In contrast, tacit knowledge is individualized and highly personal, or private, including one's values or emotions. Knowing intuitively when and how to care is an example of tacit knowledge. This type of knowledge is difficult to convey, transmit, or share with others because it consists of one's own insights, or slant on things; perceptions; intuition; sense; hunches; or gut feelings. Tacit knowledge reflects skills and beliefs, which is why it is difficult to explain or communicate to others.

Farr and Cressey (2015) used grounded theory methodology to study how professionals perceive the quality of their performance, and they found that intangible, tacit knowledge was just as important to the perception of quality of performance as more standardized rational measures of quality based on organizational policy:

> *This paper illuminates the importance of the tacit, intangible and relational dimensions of quality in actual practice. Staff values and personal and professional standards are core to understanding how quality is co-produced in service interactions. Professional experience, tacit clinical knowledge, personal standards and values, and conversations with patients and families all contributed to how staff understood and assessed the quality of their work in everyday practice.* (p. 8)

Along these same lines, references to the co-creation of knowledge have been surfacing in the literature in the last decade. Bagayogo et al. (2014) suggested that knowledge co-creation is

increasingly important to innovation in organizations and that knowledge is co-created as individuals collaborate on a shared task and share their experiences and perceptions. They reported on the use of social media support for breast and prostate cancer patients: "Individuals work together and co-create knowledge through a process that evolves temporally and is embedded in a web of interactions. Both temporal and interactional dimensions have been considered in the study of knowledge co-creation" (p. 627). The importance of knowledge cocreation is noted worldwide as evidenced in the program of study for teachers to enhance effective learning in science, technology, engineering, and mathematics (STEM) education in the knowledge co-creation program in Zambia (Ministry of Education, 2022).

How nursing students and practicing nurses learn is directly affected by their practice experiences within their own personal frame of reference. The quality of clinical decision-making is directly related to experience and knowledge. Knowledge is situational. Explicit and tacit knowledge are used to conduct assessments, diagnoses, intervention implementation, and evaluation of nursing actions for each individual patient. **Knowledge management systems (KMSs)** must blend these knowledge needs and provide knowledge bases and decision support systems to inform clinical decision-making. Each person processes and assimilates knowledge in a unique way, which is influenced by their unique perspective. What is needed is an explicit way of surfacing these nuggets of knowledge so that they can be shared among practitioners.

The Nurse as a Knowledge Worker

As we have already established, all nurses use data and information. This information is then converted to knowledge. The nurse then acts on this knowledge by initiating a plan of care, updating an existing one, or maintaining the status quo. Does this use of knowledge make the nurse a knowledge worker?

The term *knowledge worker* was first coined by Peter Drucker in his 1959 book, *Landmarks of Tomorrow* (Drucker, 1996). Knowledge work is defined as nonrepetitive, nonroutine work that entails a significant amount of cognitive activity (Sorrells-Jones & Weaver, 1999). Drucker described a knowledge worker as one who has advanced formal education and can apply theoretical and analytical knowledge. According to Drucker, the knowledge worker must be a continuous learner and a specialist in a field.

Characteristics of Knowledge Workers

According to Gent (2007), there are three types of knowledge workers: (1) knowledge consumers, (2) knowledge brokers, and (3) knowledge generators. This breakdown of knowledge workers is not mutually exclusive; instead, people transition between these states as their situations and experience, education, and knowledge change.

- Knowledge consumers are mainly users of knowledge who do not have the expertise to provide the knowledge they need for themselves. Novice nurses can be thought of as knowledge consumers who use the knowledge of experienced nurses or search information systems for the knowledge necessary to apply to their practice. As responsible knowledge consumers, they must also question and challenge what is known to help them learn and understand. Their questioning and challenging

facilitate critical thinking and the development of new knowledge.

- Knowledge brokers know where to find information and knowledge; they generate some knowledge but are mainly known for their ability to find what is needed. More experienced nurses and nursing students become knowledge brokers out of necessity because they need to know something.
- Knowledge generators are the "primary sources of new knowledge" (para. 2). They include nursing researchers and nursing experts—the people who know; they can answer questions, craft theories, find solutions to nursing problems or concerns, and innovate as part of their practice.

As knowledge work continues to stay in the forefront for healthcare professionals, it is important to realize that knowledge work

- grows and evolves with the individual, their profession, and the colleagues who invigorate them and whom they invigorate;
- requires the individual to use their knowledge in interpreting each specific patient context or situation to leverage their wisdom to initiate the appropriate action and continuously reassess the patient or situation; and
- is a catalyst for change and must be shared and honed.

As nursing recognized the knowledge work necessary to improve patient care and enhance the profession, so has medicine. Machin et al. (2022) believed that physicians must be "thinking differently, doing differently, and linking differently. This requires a raised awareness of knowledge work skills, support for their use, and promotion of linked working within communities of practice" (p. 73).

The healthcare industry, nursing profession, and patients all benefit as nurses develop nursing intelligence and intellectual capital by gaining insight into nursing science and its enactment in their practice. NI applications of databases, knowledge management

systems, and repositories, where this knowledge can be analyzed and reused, facilitate this process by enabling knowledge to be disseminated and recycled.

Getting to Wisdom

This text provides a framework that embraces knowledge so that readers can develop the wisdom necessary to apply what they have learned. Wisdom is the application of knowledge to an appropriate situation. In the practice of nursing science, one expects actions to be directed by wisdom. Wisdom uses knowledge and experience to heighten common sense and insight to exercise sound judgment in practical matters. It is developed through knowledge, experience, insight, and reflection. Sometimes wisdom is thought of as the highest form of common sense, the result of accumulated knowledge, erudition (i.e., deep, thorough learning), or enlightenment (i.e., education that results in understanding and the dissemination of knowledge). It is the ability to apply valuable and viable knowledge, experience, understanding, and insight while being prudent and sensible. Knowledge and wisdom are not synonymous: Knowledge abounds with others' thoughts and information, whereas wisdom is focused on one's own mind and the synthesis of experience, insight, understanding, and knowledge. Wisdom has been called the foundation of the art of nursing.

Some nursing roles might be viewed as more focused on some aspects than other aspects of the Foundation of Knowledge model. For example, some people might argue that nurse educators are primarily knowledge disseminators and that nurse researchers are knowledge generators. Although the more frequent output of their efforts can certainly be viewed in this way, it is important to realize that nurses use all aspects of the Foundation of Knowledge model, regardless of their area of practice. For nurse educators to be effective, they must be in the habit of constantly building and rebuilding their foundation of knowledge about nursing science. In addition, as they develop and implement curricular innovations, they must evaluate the effectiveness of those changes. In some cases, they use formal research techniques to achieve this goal and therefore generate knowledge about the best and most effective

teaching strategies. Similarly, nurse researchers must acquire and process new knowledge as they design and conduct their research studies. All nurses have the opportunity to be involved in the formal dissemination of knowledge via their participation in professional conferences, either as presenters or as attendees. In addition, some nurses disseminate knowledge by formal publication of their ideas. In the case of presenting at conferences or publishing, nurses may receive feedback that stimulates rethinking about the knowledge they have generated and disseminated, which in turn prompts them to acquire and process data and information anew.

Regardless of their practice arena, all nurses must use informatics and technology to inform and support that practice. The case scenario introduced earlier discussed Tom's use of various monitoring devices that provide feedback on the physiological status of the patient. It was also suggested that Tom might consult a clinical database or nursing practice guidelines residing in the cloud (a virtual information storage system) on a tablet or smartphone or on a clinical agency network as he develops an appropriate plan of action for his nursing interventions. Perhaps the clinical information system in the agency supports the collection of data about patients in a **relational database**, which would provide an opportunity for **data mining** by nursing administrators or nurse researchers. Data mining provides an opportunity to tease out important relationships to determine best practices to support the delivery of effective care. This text is designed to include the necessary content to prepare nurses for practice in the ever-changing and technology-laden healthcare environments. Informatics competence has been recognized for many years as being necessary to enhance clinical decision-making and improve patient care. NI research should be on the structuring and processing of patient information and the ways that these endeavors inform nursing decision-making in clinical practice. The increased use of technology to enhance nursing practice, nursing education, and nursing research will open new avenues for acquiring, processing, generating, and disseminating knowledge.

In the future, nursing research will make significant contributions to the development of nursing science. Technologies and translational research will abound, and clinical practices will continue to be evidence based, thereby improving patient outcomes and decreasing safety concerns. Schools of nursing will embrace nursing science as they strive to meet the needs of changing student populations and the increasing complexity of healthcare environments.

Summary

Nursing science influences all areas of nursing practice. This chapter provided an overview of nursing science and considered how nursing science relates to typical nursing practice roles, education, informatics, and research. The Foundation of Knowledge model was introduced as the organizing conceptual framework for this text. We reviewed key concepts of knowledge and the characteristics of knowledge workers, thus establishing nurses as knowledge workers. Finally, the relationship of nursing science to NI was discussed. In subsequent chapters, the reader will learn more about how NI supports nurses in their many and varied roles. In an ideal world, nurses would embrace nursing science as knowledge users, knowledge managers, knowledge generators, knowledge engineers, and knowledge workers.

THOUGHT-PROVOKING QUESTIONS

1. Imagine you are in a social situation and someone asks you, "What does a nurse do?" Think about how you would capture and convey in your answer the richness that is nursing science.
2. Choose a clinical scenario from your recent experience and analyze it using the Foundation of Knowledge model. How did you acquire knowledge? How did you process knowledge? How did you generate knowledge? How did you disseminate knowledge? How did you use feedback, and what was the effect of the feedback on the foundation of your knowledge?

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CHAPTER 2

Introduction to Information, Information Science, and Information Systems

OBJECTIVES

1. Reflect on the progression from data to information to knowledge.
2. Describe the term *information*.
3. Assess how information is acquired.
4. Explore the characteristics of quality information.
5. Describe an information system.
6. Explore data acquisition, or input; processing, or retrieval; analysis; and synthesis of data.
7. Assess output (e.g., reports, documents, summaries, alerts, and outcomes).
8. Describe information dissemination and feedback.
9. Define information science.
10. Assess how information is processed.
11. Explore how knowledge is generated in information science.

KEY TERMS

- 21st Century Cures Act (Cures Act)
- acquisition
- alert
- analysis

- artificial intelligence (AI)
- Artificial Intelligence of Things (AIoT)
- chief information officer
- chief technical officer
- chief technology officer
- cloud computing
- cognitive science
- communication science
- computer science
- computer-based information system
- Consolidated Health Informatics (CHI)
- data
- dissemination
- document
- electronic health information (EHI)
- electronic health record (EHR)
- Federal Health Information Exchange (FHIE)
- feedback
- health information exchange (HIE)
- Health Level Seven International (HL7)
- Health New England
- Indiana Health Information Exchange (IHIE)
- information
- information science
- information system (IS)
- information technology (IT)
- input
- interface
- Internet of Things (IoT)
- Internet2
- knowledge
- knowledge worker
- library science
- Massachusetts Health Data Consortium (MHDC)
- National Health Information Infrastructure (NHII)

- Nationwide Health Information Network (NHIN)
- Next Generation Internet (NGI)
- Office of the National Coordinator for Health Information Technology (ONC)
- outcome
- output
- processing
- Rapid Syndromic Validation Project (RSVP)
- report
- social science
- stakeholder
- summary
- synthesis
- telecommunications

Introduction

This chapter explores information, information systems (ISs), and information science as one of the building blocks of informatics (**Figure 2-1**). The key word here, of course, is *information*. Information and information processing are central to the work of health care. Healthcare professionals are known as **knowledge workers** because they deal with and process information on a daily basis to make it meaningful and inform their practice.

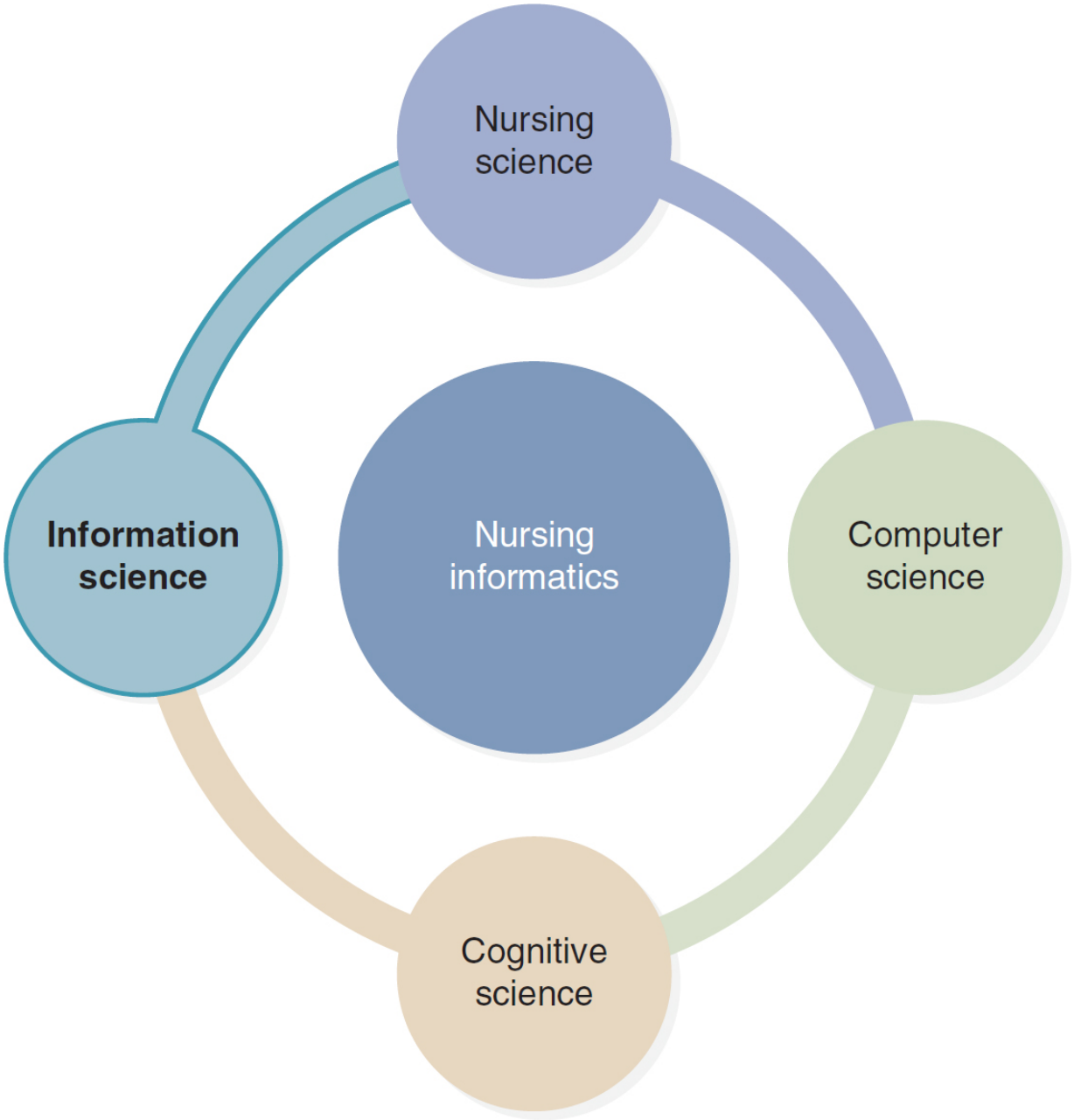


Figure 2-1 Building Blocks of Nursing Informatics

Healthcare **information** is complex and abounds with concerns and issues, such as ownership, access, disclosure, exchange, security, privacy, disposal, and dissemination. The widespread implementation of **electronic health records (EHRs)** has promoted collaboration among the public- and private-sector **stakeholders** on a wide-ranging variety of healthcare information

solutions. Some of the collaborative initiatives that we have seen over the years include **Health Level Seven International (HL7)**, **Consolidated Health Informatics (CHI)**, **National Health Information Infrastructure (NHII)**, **Nationwide Health Information Network (NHIN)**, **Next Generation Internet (NGI)**, **Internet2**, and iHealth records in the cloud. There are also **health information exchange (HIE)** systems, such as NHS Connecting for Health, eHealth Initiative, **Federal Health Information Exchange (FHIE)**, **Indiana Health Information Exchange (IHIE)**, **Massachusetts Health Data Consortium (MHDC)**, **Health New England**, State of New Mexico's **Rapid Syndromic Validation Project (RSVP)**, Southeast Michigan e-Prescribing Initiative, and Tennessee Volunteer eHealth Initiative (ASPE, n.d.; Goldstein et al., 2007; HL7 International, 2022; Western Governors University, 2021). Many of these projects and initiatives were sparked by the HITECH Act of 2011, which set the 2014 deadline for implementing EHRs and provided the impetus for HIE initiatives. In addition, the **Office of the National Coordinator for Health Information Technology (ONC)** is responsible for implementing key provisions of the **21st Century Cures Act (Cures Act)** to promote interoperability and the access, exchange, and use of **electronic health information (EHI)** and information blocking (Department of Health and Human Services, 2020). It is quite evident from the previous brief listing that there is a need to remedy today's healthcare **information technology (IT)** concerns, challenges, and issues. One of the main issues deals with how to manage healthcare information to make it meaningful. It is important to understand how people obtain, manipulate, use, share, and dispose of information. This chapter deals with the information piece of this complex puzzle.

Information

Suppose someone states the number 99.5. What does that represent? It could be a radio station or a score on a test. Now suppose someone says that Ms. Howsunny's temperature is 99.5°F. What does that convey? With that information, we now know that 99.5 is her temperature. The data (99.5) was processed into the information that 99.5°F is a specific person's temperature. **Data** are raw facts. Information is processed data that has meaning. Healthcare professionals constantly process data and information to provide the best possible care for their patients.

Many types of data exist, such as alphabetic, numeric, audio, image, and video data. Alphabetic, or alpha, data refer to letters; numeric data refer to numbers; and alphanumeric data combine both letters and numbers. These data include all text and the numeric outputs of digital monitors. Some of the alphanumeric data encountered by healthcare professionals are in the form of patients' names, identification numbers, or medical record numbers. Audio data refer to sounds, noises, or tones—for example, monitor alerts or alarms, taped or recorded messages, and other sounds. Image data include graphics and pictures, such as graphic monitor displays or recorded electrocardiograms, radiographs, magnetic resonance imaging (MRI) outputs, and computed tomography (CT) scans. Video data refer to animations, moving pictures, or moving graphics. Using these data, one may review the ultrasound of a pregnant patient; examine a patient's echocardiogram; watch an animated video for professional development; or learn how to operate a new technology tool, such as a pump or monitoring system. The data we gather, such as heart and lung sounds or X-rays, help us produce information. For example, if a patient's X-rays show a fracture, the image is then interpreted into information about the fracture, such as whether it is a spiral, compound, or hairline fracture. This information is then processed into knowledge, and a treatment plan is formulated, based on the healthcare professional's wisdom.

The integrity and quality of the data, rather than the form, are what matter. Integrity refers to whole, complete, correct, and consistent data (**Figure 2-2**). Data integrity can be compromised through human error; viruses, worms, or other computer bugs; hardware failures or crashes; transmission errors; or hackers entering the system. **Figure 2-3** illustrates some of the ways that data can be compromised. IT helps to decrease these errors by putting safeguards into place, such as backing up files on a routine basis, error detection for transmissions, and user interfaces that help people enter the data correctly. High-quality data are relevant and accurately represent their corresponding concepts. Data are dirty when a database contains errors, such as duplicate, incomplete, or outdated records. One of the authors (D.M.) found 50 cases of tongue cancer in a database that she examined for data quality. When the records were tracked down and analyzed and the dirty data removed, only one case of tongue cancer remained. In this situation, the data for the same person had been entered erroneously 49 times. The major problem was with the patient's identification number and name: the number had been changed or the name misspelled repeatedly. If researchers had taken the number of cases in that defined population as 50, they would have concluded that tongue cancer was an epidemic, which would have resulted in flawed information that is not meaningful. As this example demonstrates, it is imperative that data be clean if the goal is to have quality information. The data that are processed into information must be of high quality and integrity to create meaning to inform assessments and decision-making.

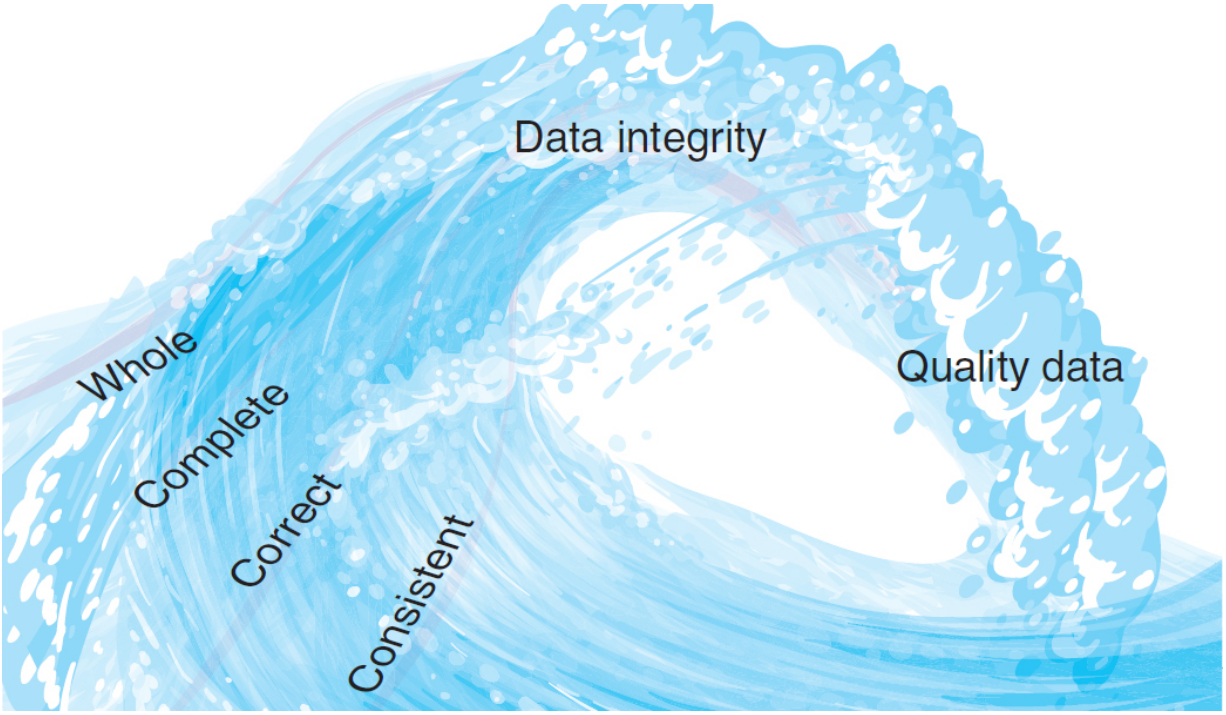


Figure 2-2 Data Integrity

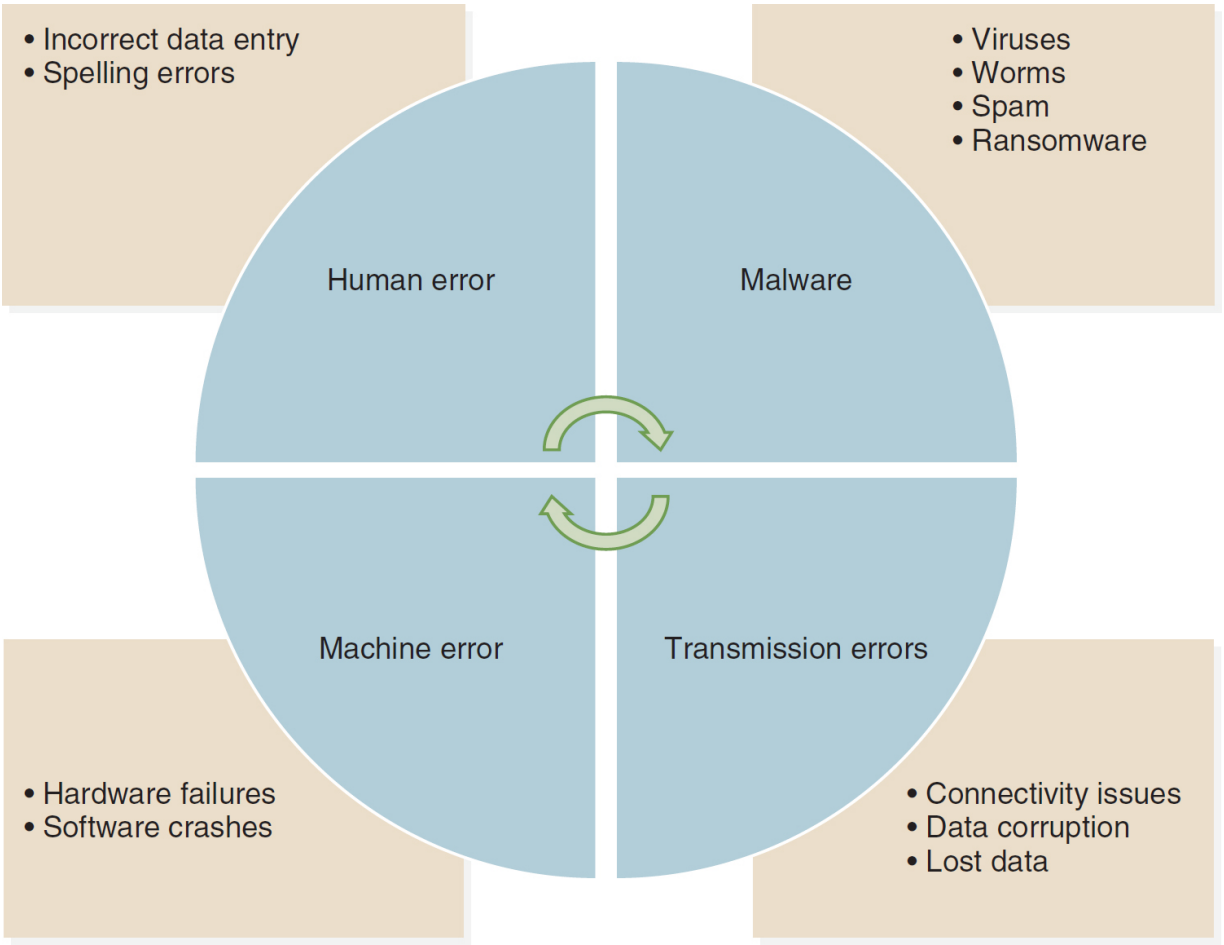


Figure 2-3 Threats to Data Integrity

Description

To be valuable and meaningful, information must be of good quality. Its value relates directly to how the information informs decision-making. Characteristics of valuable, quality information include accessibility, security, timeliness, accuracy, relevancy, completeness, flexibility, reliability, objectivity, utility, transparency, verifiability, and reproducibility.

Accessibility is a must; the right users must be able to obtain the right information at the right time and in the right format to meet their needs. Getting meaningful information to the right users at the right time is as vital as generating the information in the first place. The right users are those who are authorized to obtain the data and information they are seeking. Security is a major challenge because

unauthorized users must be blocked while at the same time authorized users must have open and easy access. (See Chapter 12, *Electronic Security*.)

Timely information means that the information is available when it is needed for the right purpose and at the right time. Knowing who won the lottery last week does not help you to know whether someone won it today. Accurate information means that there are no errors in the data and information. Relevant information is a subjective descriptor in that the information must be relevant, or applicable, to the user's needs. For example, if a healthcare provider is trying to decide whether a patient needs insulin and they have only the patient's CT scan information, then the healthcare provider would not be able to make that determination because the available information is not relevant for that specific need. However, if the healthcare provider needed information about the CT scan, then the information would be relevant.

Complete information contains all the necessary essential data. For example, if a healthcare provider needs to contact the only relative listed for the patient and that relative's contact information is listed but the approval for that person to be a contact is missing, then this information would be considered incomplete. Flexible information means that the information can be used for a variety of purposes. Information concerning the inventory of supplies on a nursing unit, for example, can be used by nurses who need to know whether an item is available for use for a patient. The nurse manager accesses this same information to help decide which supplies need to be ordered, to determine which items are used most frequently, and to do an economic assessment of any waste.

Reliable information comes from clean data that are gathered from authoritative and credible sources. Objective information is as close to the truth as one can get; it is not subjective or biased but rather is factual and impartial. For example, if someone states something, then a determination must be made as to whether that person is reliable and whether what they are stating is objective or tainted by their own perspective.

Utility refers to the ability to provide the right information at the right time to the right person for the right purpose. Transparency allows users to apply their intellect to accomplish their tasks while the tools housing the information disappear into the background. Verifiable information means that one can check to prove that the information is correct. Reproducibility refers to the ability to produce the same information again.

Information is acquired by either actively looking for it or having it conveyed by the environment. All the senses (i.e., vision, hearing, touch, smell, and taste) are used to gather **input** from the surrounding world, and as technologies mature, more and more input will be obtained through the senses. Currently, people receive information from computers (output) through vision, hearing, or touch (input), and the response (output) to the computer (input) is the **interface** with technology. Gesture recognition is increasing, and interfaces that incorporate such technology will change the way people become informed. Daily, many people accessing the internet are seeking or imparting information. Individuals are constantly discovering or rediscovering, learning or relearning, or becoming informed or reinformed and purging outdated information as new information is acquired. The information acquired through these processes is added to their personal knowledge base. **Knowledge** is the awareness and understanding of a set of information and ways that information can be made useful to support a specific task or arrive at a decision. This knowledge building is an ongoing process engaged in while a person is conscious and going about their normal daily activities.

Information Science

Information science has evolved over the past 50 or so years as a field of scientific inquiry and professional practice. It can be thought of as the science of information, studying the application and usage of information and knowledge in organizations and the interface or interaction between people, organizations, and ISs. This extensive, interdisciplinary science integrates features from **cognitive science**, **communication science**, **computer science**, **library science**, and **social science**. Information science is primarily concerned with the input, processing, output, and feedback of data and information through technology integration with a focus on comprehending the perspective of the stakeholders involved and then applying IT as needed. It is systemically based and deals with the big picture, rather than with the individual pieces, of technology.

Information science can also be related to determinism. Specifically, it is a response to technological determinism, which is the belief that technology develops by its own laws and realizes its own potential, limited only by the material resources available, and that it therefore must be regarded as an autonomous system that controls and ultimately permeates all other subsystems of society. In addition, "The [determinism] theory holds that the universe is utterly rational because complete knowledge of any given situation assures that unerring knowledge of its future is also possible" (Britannica, n.d., para. 1).

This approach sets the tone for the study of information as it applies to itself, the people, the technology, and the varied sciences that are contextually related based on the needs of the setting or organization. What is important is the interface between the stakeholders and their systems and the ways they generate, use, and locate information. According to Cornell University (n.d.), information science explores "the interactions between people and technology, how technology is shaping individual lives and social groups, as well as how the ways that people use technology can

shape new developments" (para. 1). Information science is an interdisciplinary, people-oriented field that explores and enhances the interchange of information to transform society through communication science, computer science, cognitive science, library science, and social science. Society is dominated by the need for information, and knowledge and information science focus on systems and individual users by fostering user-centered approaches that enhance society's information capabilities by effectively and efficiently linking people, information, and technology. This collaborative user-centered approach affects the configuration and mix of organizations and influences the nature of work–namely, how knowledge workers interact with and produce meaningful information and knowledge.

Information Processing

Information science enables the **processing** of information, which links people and technology. Humans are organic ISs, constantly acquiring, processing, and generating information or knowledge in their professional and personal lives. In fact, this high degree of knowledge characterizes humans as extremely intelligent organic machines. The premise of this text revolves around this concept, and the text is organized on the basis of the Foundation of Knowledge model, whose concepts are knowledge **acquisition**, knowledge processing, knowledge generation, and knowledge dissemination.

Information is data that are processed using knowledge. For information to be valuable or meaningful, it must be accessible, accurate, timely, complete, cost-effective, flexible, reliable, relevant, simple, verifiable, and secure. We are in an era distinguished by the explosive proliferation of information whereby we must assess relevancy as we process information, based on our knowledge and on each specific contextual situation. Knowledge is the awareness and understanding of an information set and ways that information can be made useful to support a specific task or arrive at a decision. As an example, if an architect were going to design a building, part of the knowledge necessary for developing a new building would be understanding how the building will be used, what size of building would be needed compared to the available building space, and how many people would have or need access to this building. Therefore, the work of choosing or rejecting facts based on their significance or relevance to a particular task, such as designing a building, is also based on a type of knowledge used in the process of converting data into information. Information can then be considered data made functional through the application of knowledge. Knowledge is generative (having the ability to originate and produce, or generate) in nature. Knowledge must also be viable. Knowledge viability refers to applications that offer accessible, accurate, and timely information

obtained from a variety of resources and methods and presented in a manner to provide the necessary elements to generate knowledge.

Information science and computational tools are extremely important in enabling the processing of data, information, and knowledge in health care. In the healthcare environment, the hardware, software, networking, algorithms, and human organic ISs work together to create meaningful information and generate knowledge. The links between information processing and scientific discovery are paramount. However, without the ability to generate practical results that can be disseminated, the processing of data, information, and knowledge is for naught. The ability of machines (inorganic ISs) to support and facilitate the functioning of people (human organic ISs) is what refines, enhances, and evolves nursing practice by generating knowledge. This knowledge represents five *rights*: the right information, accessible by the right people in the right settings, applied the right way at the right time.

An important and ongoing process is the struggle to integrate new knowledge with old knowledge to enhance wisdom. Wisdom is the ability to act appropriately; it assumes actions directed by one's own wisdom. Wisdom uses knowledge and experience to heighten common sense and insight to exercise sound judgment in practical matters. It is developed through knowledge, experience, insight, and reflection. Sometimes wisdom is thought of as the highest form of common sense, which results from accumulated knowledge, or erudition (i.e., deep, thorough learning) or enlightenment (i.e., education that results in understanding and the dissemination of knowledge). It is the ability to apply valuable and viable knowledge, experience, understanding, and insight while being prudent and sensible. Knowledge and wisdom are not synonymous because knowledge abounds with others' thoughts and information, whereas wisdom is focused on one's own mind and the synthesis of one's own experience, insight, understanding, and knowledge.

If clinicians are inundated with data without the ability to process them, the situation results in too much data and too little wisdom. Consequently, it is crucial that clinicians have viable ISs at their fingertips to facilitate the acquisition, sharing, and use of knowledge

while maturing their wisdom, and it is this process that leads to empowerment.

Information Science and the Foundation of Knowledge

Information science is multidisciplinary in that it encompasses aspects of computer science, cognitive science, social science, communication science, and library science to deal with obtaining, gathering, organizing, manipulating, managing, storing, retrieving, recapturing, disposing of, distributing, and broadcasting information. Information science encompasses everything that pertains to information and can be defined as the study of ISs. This science originated as a subdiscipline of computer science as practitioners sought to understand and rationalize the management of technology within organizations. It has since matured into a major field of management and is now an important area of research in management studies. Moreover, information science has expanded its scope to examine the human–computer interaction and the interactions of people, ISs, and corporations. It is taught at all major universities and business schools worldwide.

Modern-day organizations have become intensely aware of the fact that information and knowledge are potent resources that must be cultivated and honed to meet their needs. Thus, information science, or the study of ISs—that is, the application and usage of knowledge—focuses on why and how technology can be put to best use to serve the information flow within an organization.

Information science affects information interfaces and influences how people interact with information and subsequently develop and use knowledge. The information a person acquires is added to their knowledge base. Knowledge is the awareness and understanding of an information set and the ways that information can be made useful to support a specific task or arrive at a decision.

Healthcare organizations are affected by and rely on the evolution of information science to enhance the recording and processing of routine and intimate information while facilitating human-to-human

and human-to-system communication, delivery of healthcare products, dissemination of information, and enhancement of the organization's business transactions. Unfortunately, the benefits and enhancements of information science technology have also brought to light new risks, such as glitches, loss of information, and hackers who can steal identities and information. Solid leadership, guidance, and vision are vital to the maintenance of cost-effective business performance and safe, cutting-edge information technologies for the organization. This field studies all facets of the building and use of information. The emergence of information science and its effect on information have also influenced how people acquire and use knowledge.

Information science has already had a tremendous effect on society and will undoubtedly expand its sphere of influence further as it continues to evolve and innovate human activities at all levels. What visionaries only dreamed of is now possible and part of reality, but the future has yet to fully unfold in this important arena.

Introduction to Information Systems

Consider the following scenario: You have just been hired by a large healthcare facility. You enter the personnel office and are told that you must learn a new language to work on the unit where you have been assigned, a language that is particular to this unit only. If you had been assigned to a different unit, you would have needed to learn another language that is specific to that unit, and so on. Because of the differences in various units' languages, interdepartmental sharing and information exchange (known as interoperability) are severely hindered.

This scenario might seem far-fetched, but it is how workers once operated in health care—in silos. There was a system for the laboratory, one for finance, one for clinical departments, and so on. As healthcare organizations have come to appreciate the importance of communication, tracking, and research, however, they have developed or purchased ISs that can be integrated to handle the needs of the entire organization.

Information and IT have become major resources for all types of organizations, and health care is no exception (**Table 2-1**). IT helps to shape a healthcare organization in conjunction with personnel, money, materials, and equipment. Many healthcare facilities have hired **chief information officers** (CIOs) or **chief technical officers** (CTOs), also known as **chief technology officers**. The CIO is involved with the IT infrastructure, and sometimes this role is expanded to include the position of chief knowledge officer. The CTO is focused on organizationally based scientific and technical issues and is responsible for technological research and development as part of the organization's products and services. The CTO and CIO must be visionary leaders for the organization because so much of the business of health care relies on solid infrastructures that generate potent and timely information and knowledge. In some organizations, the CTO and CIO positions are interchangeable, but in others the CTO reports to the CIO. These positions will become

critical roles as companies continue to shift from being product to knowledge oriented and as they begin emphasizing the production process itself rather than the product. In health care, ISs must be able to handle the volume of data and information necessary to generate the needed information and knowledge for best practices because the goal is to provide the highest-quality patient care.

TABLE 2-1 Examples of Information Systems

Information System	How It Is Used
Clinical information system (CIS)	Comprehensive and integrative system that manages the administrative, financial, and clinical aspects of a clinical facility; a CIS should help to link financial and clinical outcomes. An example is the EHR.
Decision support system (DSS)	Organizes and analyzes information to help decision-makers formulate decisions when they are unsure of their decisions' possible outcomes. After gathering relevant and useful information, the DSS develops what-if models to analyze the options.
Executive information system (EIS) or executive support system	Collects, organizes, analyzes, and summarizes vital information to help executives with strategic decision-making. Provides a quick view of all strategic business activities to help executives analyze the milieu in which the organization operates to identify patterns and long-term trends to plan appropriate strategies and courses of action.
Geographic information system (GIS)	Collects, manipulates, analyzes, and generates information related to geographic locations or the surface of the Earth; provides output in the form of virtual models, maps, or lists.
Management information system (MIS)	Provides summaries of internal sources of information, such as information from the transaction processing

	system, and develops a series of routine reports for decision-making.
Knowledge work system (KWS)	Promotes the creation of knowledge by providing an interface that is user friendly and houses the necessary tools internally and that includes access to external tools, such as databases. It is designed to simplify the acquisition of information and therefore to facilitate the integration of knowledge and technical skills into the organization. Examples of a KWS would be an external virtual reality (VR) system or internal financial workspace.
Office system	Facilitates communication and enhances the productivity of users who need to process data and information.
Transaction processing system (TPS)	Processes and records routine business transactions, such as a billing system to create and send invoices to customers or a payroll system to generate employees' pay stubs and wage checks and calculate tax payments.
Hospital information system (HIS)	Manages the administrative, financial, and clinical aspects of a hospital enterprise. It should help to link financial and clinical outcomes.

Information Systems

ISs can be manually based, but for the purposes of this text, the term refers to **computer-based information systems**. These ISs are combinations of computer hardware, software, telecommunications, networks, users, and procedures. The hardware, or computer equipment, performs the input, processing, and output activities, based on the software that controls the operation of the computer. Additional software tools, such as databases, organize the facts and information collected and offer storage, retrieval, and modifications to and deletion of data capabilities. Telecommunications provide a mechanism for communicating. The networks connect designated computers within

hospitals across the country and around the world. The largest computer network in the world is the internet. The internet users (people) are responsible for designing, developing, programming, operating, managing, and maintaining the system. They collect, create, input, analyze, and distribute meaningful or useful data and information. They also devise the procedures, strategies, policies, methods, and rules for using the system. Along the same lines, ISs have been defined as "a collection of interconnected elements that gather, process, store and distribute data and information while providing a feedback structure to meet an objective" (Stair & Reynolds, 2016, p. 4). Carnegie Melon University (2022) described the field of ISs as being involved with the "effective design, delivery, and use of information and communications technologies to solve problems for companies, governments, and society" (para. 5). ISs are designed for specific purposes within organizations. They are only as functional as the decision-making capabilities, problem-solving skills, and programming potency built into them coupled with the quality of the data and information that are inputted into them. The capability of the ISs to disseminate, provide feedback, and adjust the data and information is based on these dynamic processes and is what sets them apart. It is important to ethically implement the ISs by appreciating and evaluating the human effect of these technologies both on the users and on their institutions. The ISs should be user-friendly entities that provide the right information at the right time, in the right place, and to the right person. ISs acquire data, or inputs; process data through the retrieval, **analysis**, or **synthesis** of those data; disseminate, or output, information in the form of reports, documents, summaries, alerts, prompts, or **outcomes**; and provide for responses, or feedback. Input, or data acquisition, is the activity of collecting and acquiring raw data. Input devices include combinations of hardware, software, and telecommunications, including keyboards, light pens, touch screens, mice or other pointing devices, automatic scanners, and machines that can read magnetic ink characters or lettering. To watch a pay-per-view movie, for example, the viewer must first input the chosen movie, verify the purchase, and pay with a method

approved by the vendor. The IS must acquire this information before the viewer can receive the movie.

Processing, which is the retrieval, analysis, or synthesis of data, refers to the alteration and transformation of the data into useful information and outputs. The processing of data can range from storing it for future use; to comparing the data, making calculations, or applying formulas; to taking selective actions. Processing devices consist of combinations of hardware, software, and telecommunications and include processing chips, in which the central processing unit (CPU) and main memory are housed. Some of these chips are quite ingenious. In 2005, it was hoped that the bunny chip could save the pharmaceutical industry money while sparing "millions of furry creatures, with a chip that mimics a living organism" (Schupak, 2005, para. 1). Other companies have developed environments, or biological ISs, that reside on chips and truly mimic the functioning of the human body. Researchers can use these environments to test for both the harmful and the beneficial effects of drugs, including those that are considered experimental and that could be harmful if used in human and animal testing. Such chips also allow researchers to monitor a drug's toxicity in the liver and other organs.

One patented HμREL microfluidic biochip comprises an arrangement of separate but fluidically interconnected "organ" or "tissue" compartments. Each compartment contains a culture of living cells drawn from or engineered to mimic the primary functions of the respective organ or tissue of a living animal. Microfluidic channels permit a culture medium that serves as a blood surrogate to recirculate, just as in a living system, driven by a microfluidic pump. The geometry and fluidics of the device are fashioned to simulate the values of certain related physiological parameters found in the living creature. Drug candidates or other substrates of interest are added to the culture medium and allowed to recirculate through the device. The effects of drug compounds and their metabolites on the cells within each respective organ compartment are then detected by measuring or monitoring key physiological events. The cell types used may be derived from either standard cell culture lines

or primary tissues. In 2019, HμREL and Cyprotex partnered to collaborate and expand their research agendas. As new technologies arise from collaboration and as partnerships continue to evolve, more and more robust ISs that can handle a variety of biological and clinical applications are being developed. Currently, pharmaceutical companies and the healthcare community are exploring assets that fall into the gray area between being classified as a drug or a device, where their classification can have regulatory and financial consequences (Castañeda, 2022; Jimenez, 2022). Jimenez suggested that the intended use could be indicative of the classification as a device or drug, but it is still questionable or debatable. Think of the IS needed for the use and assessment of drugs and devices being used to diagnose, mitigate, treat, and monitor patients.

Returning to the example of the movie rental, the IS must verify the data entered by the viewer and then process the request by following the steps necessary to provide access to the movie that was ordered. This processing must be instantaneous in today's world, where everyone wants everything *now*. After the data are processed, they are stored. In this case, the rental must also be processed so that the vendor receives payment for the movie, whether electronically, via a credit card or checking account withdrawal, or by generating a bill for payment.

Output, or **dissemination**, produces helpful information, which can be in the form of reports, **documents**, summaries, alerts, or outcomes. A **report** is designed to inform and is generally tailored to the context of a given situation or user or user group. Reports may include charts, figures, tables, graphics, pictures, hyperlinks, references, or other documentation necessary to meet the needs of the user. A document represents information that can be printed, saved, or emailed or otherwise shared or displayed. A **summary** is a condensed version of the original information that is designed to highlight the major points. An **alert** comprises warnings, feedback, or additional information necessary to assist the user in interacting with the system. An outcome is the expected result of input and processing. Output devices are combinations of hardware, software,

and **telecommunications** and include sound and speech synthesis outputs, printers, and monitors.

Continuing with the example of the movie rental, the IS must be able to provide the consumer with the movie ordered when the consumer wants it and somehow notify the consumer that they have indeed purchased the movie and are granted access. The IS must also be able to generate payment, either electronically or by generating a bill, while storing the transactional record for future use.

Feedback, or a response, is a reaction to the inputting, processing, and outputting. In ISs, feedback refers to information from the system that is used to make modifications in the input, processing actions, or outputs. In the example of the movie rental, what if the consumer accidentally entered the same movie order three times instead of only once? The IS would determine that more than one movie order is out of range for the same movie order at the same time, and it would provide feedback. Such feedback is used to verify and correct the input. If undetected, the viewer's error would result in an erroneous bill and decreased customer satisfaction while creating more work for the vendor, which would have to engage in additional transactions with the customer to resolve this problem. Section IV, *Nursing Informatics Practice Applications: Care Delivery*, in this text provides detailed descriptions of CISs that operate on these same principles to support healthcare delivery.

Summary

ISs deal with the development, use, and management of an organization's IT infrastructure. An IS acquires data, or inputs; processes data through the retrieval, analysis, or synthesis of those data; disseminates, or outputs, the data in the form of reports, documents, summaries, alerts, or outcomes; and provides for responses, or feedback. Quality decision-making and problem-solving skills are vital to the development of effective and valuable ISs. Today's organizations now recognize that their most precious asset is their information, as represented by their employees, experience, competence, and innovative approaches, all of which are dependent on a robust information network that encompasses the IT infrastructure.

In an ideal world, all ISs would be fluid in their ability to adapt to any and all users' needs. They would be internet oriented and global so that resources are available to everyone. Think of **cloud computing**. It is just the beginning point from which ISs will expand and grow in their ability to provide meaningful information to their users. As technologies advance, so will the skills and capabilities to comprehend and realize what ISs can become. As wearable tracking technologies and other health-related mobile applications expand, more robust and timely health data will be generated, and these data will need to be processed into meaningful information. "Practitioners and medical researchers can look forward to technologies that enable them to apply data analysis to develop new insights into finding cures for difficult diseases. Healthcare CIOs and other IT leaders can expect to be called upon to manage all the new data and devices that will be transforming healthcare as we know it" (Schindler, 2015, para. 2). Devices with sensors communicating with each other are collectively known as the **Internet of Things (IoT)**, which expands the future possibilities for health care tremendously. The IoT is made up of complex social, technical, procedural, and policy considerations that are constantly

evolving for a variety of users such as healthcare professionals (Airtel Business, 2022). The IoT enables the connecting and exchanging of data with other devices and systems from anywhere to anywhere. This IoT can share and collect data and information with minimal human intervention. Essentially, the sensor-collected data are transmitted to another technology, which triggers an action or an alert that prompts feedback for an action. Now think about the combination of **artificial intelligence (AI)** and the IoT, called the **Artificial Intelligence of Things (AIoT)**, which represents the nurturing of the development of the intellectual properties of the devices we use. This blending of AI and the IoT infrastructure helps us attain more efficient and effective operations, enhances human–technology interfacing and interactions, and improves data and information management and analytics (Yasar et al., 2023). It will be important to follow the continued evolution of AIoT within and outside of the healthcare arena. It is essential to continue to develop and refine functional, robust, and visionary ISs that meet the current meaningful information needs while evolving systems that are even better prepared to handle the future information and knowledge needs of the healthcare industry.

THOUGHT-PROVOKING QUESTIONS

1. How do you acquire information? Choose two hours out of your busy day to notice all the information that you receive from your environment. Keep a diary indicating where the information came from and how you knew it was information and not data.
2. Reflect on an IS with which you are familiar, such as the automatic banking machine. How does this IS function? What are the advantages of using this system (i.e., why not use a bank teller instead)? What are the disadvantages? Are there enhancements that you would add to this system?
3. In health care, think about a typical day of practice, and describe the setting. How many times do nurses interact with ISs? What are the ISs that nurses interact with, and how do they access them? Are the ISs at

the bedside, handheld, or station based? How do their location and ease of access affect nursing care?

4. Briefly describe an organization and discuss how our need for information and knowledge affects the configuration and interaction of that organization with other organizations. Also, discuss how the need for information and knowledge influences the nature of work or how knowledge workers interact with and produce information and knowledge in this organization.
5. If you could meet only four of the *rights* discussed in this chapter, which one would you omit and why? Also, provide your rationale for each right you chose to meet.
6. Describe how information science relates to nursing science.
7. Examine your personal and professional environments and assess the AI, IoT, and AIoT devices you use in each setting.

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CHAPTER 3

Computer Science and the Foundation of Knowledge Model

OBJECTIVES

1. Describe the essential components of computer systems, including hardware and software.
2. Recognize the rapid evolution of computer systems and the benefit of keeping up to date with current trends and developments.
3. Analyze how computer systems function as tools for managing information and generating knowledge.
4. Define the concept of human–technology interfaces.
5. Assess how computers can support collaboration, networking, and information exchange.

KEY TERMS

- acquisition
- active-matrix organic light-emitting diode (AMOLED)
- application
- arithmetic logic unit
- bandwidth
- basic input/output system (BIOS)
- binary system
- bit

- broadband
- byte
- cache memory
- central processing unit (CPU)
- Chromebook
- cloud computing
- cloud storage
- communication software
- compact disk read-only memory (CD-ROM)
- compact disk-recordable (CD-R)
- compact disk-rewritable (CD-RW)
- compatible
- computer
- computer science
- conferencing software
- creativity software
- database
- desktop
- desktop publishing
- digital video disk-recordable (DVD-R)
- digital video disk-rewritable (DVD-RW)
- distributed network
- double data rate synchronous dynamic random-access memory (DDR SDRAM)
- dynamic random-access memory (DRAM)
- electronically erasable programmable read-only memory (EEPROM)
- email
- encryption
- exabyte (EB)
- execute
- extensible
- far-field communication
- firmware
- flash memory
- gigabyte (GB)
- gigahertz

- graphical user interface (GUI)
- graphics card
- haptics
- hard disk
- hard drive
- hardware
- head-mounted display (HMD)
- information
- Information Age
- infrastructure as a service (IaaS)
- in-plane switching liquid-crystal display (IPS LCD)
- instant message (IM)
- keyboard
- knowledge
- laptop
- local area network (LAN)
- main memory
- megabyte (MB)
- memory
- metaverse
- microprocessor
- millions of instructions per second (MIPS)
- mobile
- mobile computing
- mobile device
- mobile health (mHealth)
- modem
- monitor
- motherboard
- mouse
- MPEG-1 Audio Layer-3 (MP3)
- near field communication (NFC)
- network
- office suite
- open source

- operating system (OS)
- peripheral component interconnection (PCI)
- personal computer (PC)
- petabyte (PB)
- platform as a service (PaaS)
- plug-and-play
- portable
- power supply
- presentation
- processing
- processor
- productivity software
- professional development
- programmable read-only memory (PROM)
- quantum bit (qubit)
- quantum computing
- QWERTY
- radio-frequency identification (RFID)
- random-access memory (RAM)
- read-only memory (ROM)
- security
- Small Computer System Interface (SCSI)
- software
- software as a service (SaaS)
- sound card
- spreadsheet
- synchronous dynamic random-access memory (SDRAM)
- technology
- terabyte (TB)
- throughput
- touch pad
- touch screen
- universal serial bus (USB)
- USB flash drive
- user-friendly

- user interface
- video adapter card
- virtual memory
- virtual private network (VPN)
- wearable technology
- Wi-Fi
- Wi-Fi hotspot
- wide area network (WAN)
- wireless
- wireless mobile computing
- wisdom
- word processing
- World Wide Web (WWW)
- yottabyte (YB)
- zettabyte (ZB)

Introduction

In this chapter, the discipline of computer science, which is one of the building blocks of nursing informatics, is introduced through a focus on computers and the hardware and software that comprise these evolving systems (**Figure 3-1**). Computer science offers extremely valuable tools that, when used skillfully, can facilitate the **acquisition** and manipulation of data and **information** by nurses who then can synthesize the data into an evolving knowledge and **wisdom** base. This process can facilitate **professional development** and the ability to apply evidence-based practice decisions within nursing care, and if the results are disseminated and shared, they can also advance the professional knowledge base.

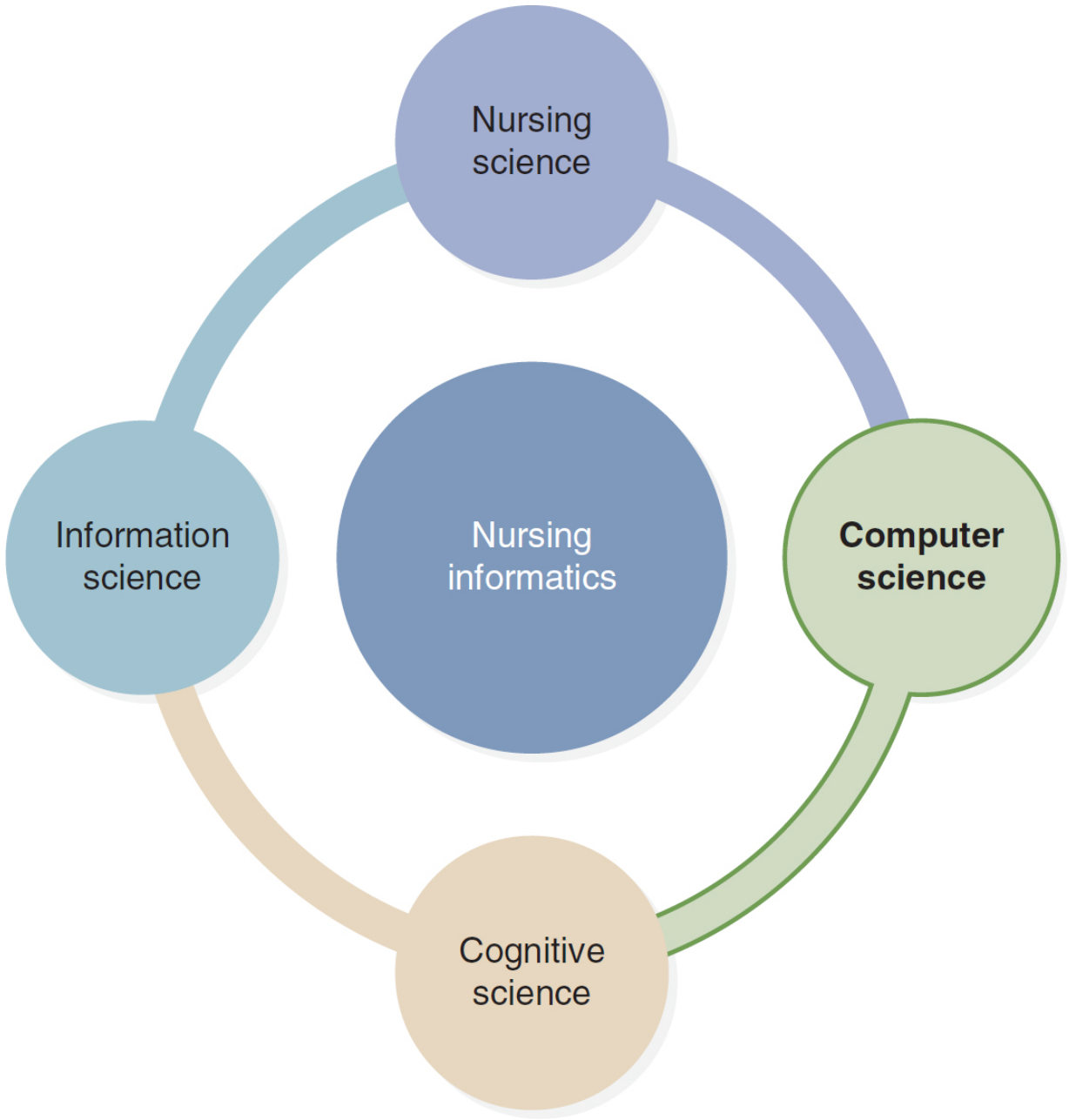


Figure 3-1 Building Blocks of Nursing Informatics

This chapter begins with a look at common computer hardware, followed by a brief overview of operating, productivity, creativity, and communication software. It concludes with a glimpse at how computer systems help to shape knowledge and collaboration and an introduction to human–technology interface dynamics.

The Computer as a Tool for Managing Information and Generating Knowledge

Throughout history, various milestones have signaled discoveries, inventions, and philosophical shifts that spurred a surge in **knowledge** and understanding within the human race. The advent of the computer is one such milestone, which has sparked an intellectual metamorphosis whose boundaries have yet to be fully understood. Computer **technology** has ushered in what has been called the **Information Age**, an age when data, information, and knowledge are both accessible and manipulable by more people than ever before. How can a mere machine lead to such a revolutionary state of knowledge potential? To begin to answer this question, we need to examine the basic structure and components of computer systems.

Essentially, a **computer** is an electronic information-processing machine that serves as a tool with which to manipulate data and information. The easiest way to begin to understand computers is to realize that they are input–output systems. These unique machines accept data input via a variety of devices, process data through logical and arithmetic rendering, store the data in **memory** components, and output data and information to the user.

"Computing has changed the world more than any other invention of the past hundred years, and has come to pervade nearly all human endeavors. Yet, we are just at the beginning of the computing revolution; today's computing offers just a glimpse of the potential impact of computers" (Evans, 2019, p. 3). Computer manufacturers and researchers, such as Intel, have identified the need to design computers to mask this growing complexity and sophistication by enhancing ease of use or **user-friendly** aspects. This is being achieved by honing hardware and software capabilities until they work together seamlessly to ensure user-friendly, intuitive tools for users of all levels of expertise. An example is in the haptic

technologies, evolving hardware and software that will increase the experiential aspects of computing. **Box 3-1** provides information about haptic technology.

BOX 3-1 HAPTIC TECHNOLOGY

Dee McGonigle

The science of **haptics** deals with artificial touch technology. Haptics is touted as the evolving technology needed to advance virtual reality (VR) and augmented reality (AR) beyond just seeing and hearing within a virtual world in VR or the floating interfaces of AR to actually feel what you are touching or what comes in contact with you if you have a body suit. On its website, Immersion states that "real, immersive, and more appealing: haptics adds value to the experience" (www.immersion.com), thus enhancing digital experiences. No matter what reality we are experiencing, our emotions and experiences are heightened, or come alive, through our sense of touch, and it is haptic technology that allows the user to reproduce that sensation. The user can feel the technology, or experience, through a series of actions, including force and vibration or carefully controlled haptic virtual objects, and as the technology improves, so will the virtual feeling that improves the immersive experience. Effective learning environments will provide an excellent integration of visual and audible perceptions with tactile sensations.

Haptic technology is being built into partial- and full-body suits. According to VR Electronics, its wearable "TESLASUIT training solution provides outputs from haptic feedback and climate control to users and receives inputs from motion capture and biometrics. With our software and partner ecosystem, this technology is a complete solution for improving human performance" (https://teslasuit.io). This suit can be used by rehabilitation professionals to facilitate the user's learning or relearning physical actions and training their reflexes.

Haptic gloves as well continue to evolve.

VR Life reviewed the top haptic gloves for VR in 2022 (Bithrey, 2022). VR Life thinks the best gloves are the SensoryX VR Free Gloves, which can work with all VR HMDs. The SensoryX website (https://sensoryx.tech) states that they are the tracking solution for the metaverse and the user interaction of the future.

LEAPMotion, a company that designs motion control devices, wants to "build a more human reality." The Ultraleap Gemini is the fifth-generation hand-tracking platform, which has improved tracking for both hands, especially when they are close together, interacting, or actually overlapping

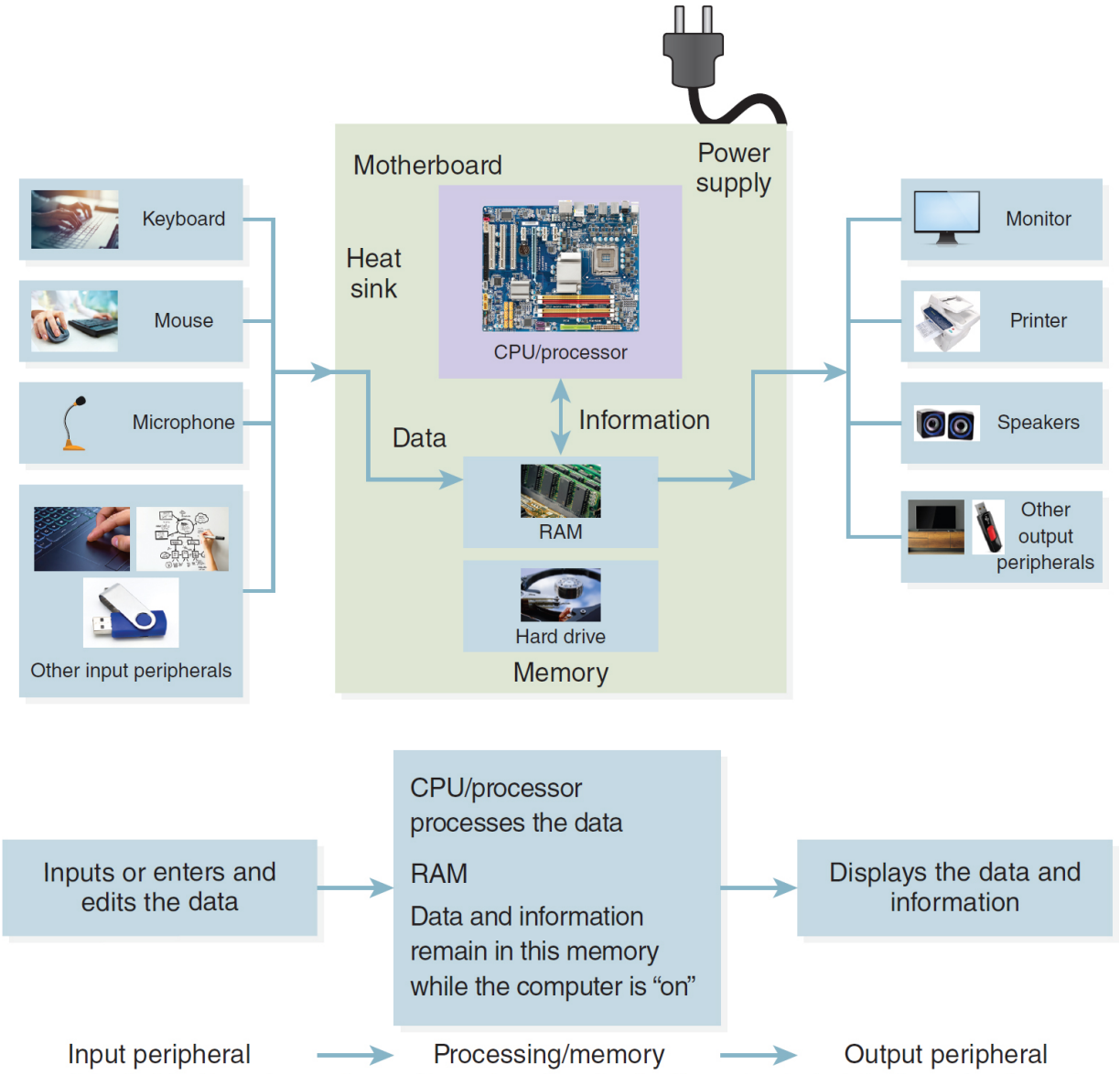
(https://developer.leapmotion.com/about-gemini). The Make Use Of website describes the Oculus Quest as being capable of using the headset's external cameras to track your finger motion and hand movement to use as input (Stegner, 2022).

Reflect on the ramifications of the computer and digital enhancements for health care and education, especially as they relate to the haptic experience and wearables.

The goal for vendors that provide computer systems and software is to decrease the learning curve for users while enhancing their capacity to manipulate the system to meet their computing needs. Therefore, the complexity of the operation is concealed by its ease of use.

Computers are universal machines because they are general-purpose, symbol-manipulating devices that can perform any task represented in specific programs. For instance, they can be used to draw an image, calculate statistics, write an essay, or record nursing care data. In a nutshell, computers can be used for data and information storage, retrieval, analysis, generation, and transformation.

Most computers are based on scientist John von Neumann's model of a processor–memory–input–output architecture. This basic configuration and the components are briefly reviewed (see **Table 3-1** and **Figure 3-2**).



Keyboard © Undrey/Shutterstock; mouse © Pressmaster/Shutterstock; microphone © VectorShow/Shutterstock; touch pad © donfiore/Shutterstock; pen drawing a diagram © Syda Productions/Shutterstock; USB drive © DecemberDah/Shutterstock; CPU © Péter Gudella/Dreamstime.com; RAM © NorGal/Shutterstock; hard drive © mike mols/Shutterstock; monitor © Leone_V/Shutterstock; printer © Billion Photos/Shutterstock; speakers © Krailurk Warasup/Shutterstock; TV © JTal/Shutterstock; flash drive © Ksander/Shutterstock

Figure 3-2 Computer Components

Description

TABLE 3-1 Components

Component	Description
Hardware	Actual physical body of the computer and its components.
Central processing unit (CPU)	CPU is an older term for the **processor** and **microprocessor**. Sometimes conceptualized as the brain, or command center, directing the actions of all computer components; **executes**, calculates, and processes the binary computer code (which consists of various configurations of 0s and 1s), which are functions that are instigated by the operating system (OS) and other **applications** on the computer. Manages both incoming and outgoing data that are processed across components. The processor contains specific mechanical units, including registers, **arithmetic logic units**; a floating point unit; control circuitry; and cache memory. **Cache memory** is extremely quick memory that holds whatever data and code are being used at any one time. The speed and power of a processor are measured in **gigahertz** (1 GHz). Multicore microprocessors, or chips that combine two or more processors, have become a standard in both personal and professional computers. For more information, refer to UL Benchmarks (2023).
Motherboard	Known as the central nervous system of the computer, it facilitates communication among all the computer components since the components are connected to it in some way (either directly via local sockets, attached directly to it, or connected via cables). These components include **universal serial bus (USB)**, Ethernet network, and integrated graphics controllers.
Power supply	A critical component because it provides the essential electrical energy needed to allow a computer to operate.

Component	Description
Hard disk, or **hard drive**	The rigid **hard disks** acting as permanent data storage holding gigabytes (GB) or terabytes (TB) of data, information, documents, and programs saved on the computer, even when the computer is turned off. These disk drives are not infallible, however, so backing up important data is imperative.
Random-access memory (RAM)	RAM is considered to be volatile memory because it is a temporary storage system that allows the processor to access program codes and data while working on a task. The contents of RAM are lost once the system is rebooted or shut off intentionally or because of a loss of power. Computers can gain more RAM via graphics cards and other expansion cards. A certain portion of the RAM, called the **main memory**, serves the hard disk and facilitates interactions between the hard disk and the CPU. Main memory is provided by **dynamic random-access memory (DRAM)** and **synchronous dynamic random-access memory (SDRAM)**. Newer chips, **double data rate synchronous dynamic random-access memory (DDR SDRAM)**, allow for greater bandwidth and twice the transfers per the unit of time of the computer's internal clock.
Read-only memory (ROM)	ROM stores saved data and is critical in the working of the computer's OS and other activities. ROM is stored primarily on the motherboard, but it may also be available through the graphics card, other expansion cards, and peripherals. In recent years, rewritable ROM chips, which may include other forms of ROM, such as **programmable read-only memory (PROM)**, erasable ROM, **electronically erasable programmable read-only memory (EEPROM)**, and **flash memory** (a variation of EEPROM), have become available.
Basic input/output system (BIOS)	BIOS is a specific type of ROM used by the computer when it first boots up to establish basic communication among the processor, motherboard, and other components. It controls the computer from the time the machine is switched on until the primary OS takes over. The **firmware** initializes

Component	Description
	the hardware and boots (loads and executes) the primary OS.
Virtual memory	A special type of memory that is stored on the hard disk to provide temporary data storage so that data can be swapped in and out of the RAM as needed.
Peripheral component interconnection (PCI) bus	This component is important for connecting additional plug-in components to the computer. It uses a series of slots on the motherboard to allow **peripheral component interconnection (PCI)** card plug-ins.
Small computer system interface (SCSI)	The SCSI component provides the means to attach additional devices, such as scanners and extra hard drives.
DVD/CD drives	The **compact disk read-only memory (CD-ROM)** drive reads and records data to portable CDs. The light reflected on the disk is directed by a system of lenses to a photodetector, which converts the light pulses into an electrical signal; this signal is then decoded by the drive electronics to the motherboard. There are **compact disk-recordable (CD-R)**, **compact disk-rewritable (CD-RW)**, **digital video disk-recordable (DVD-R)**, and **digital video disk-rewritable (DVD-RW)** drives.
Flash or USB flash drive	This portable memory device uses electronically erasable, programmable ROM to provide fast, permanent memory. The **USB flash drive** is typically a removable and rewritable device that includes flash memory and an integrated USB interface.
Modem	Can be situated either externally or internally; enables internet connectivity via a cable connection through network adapters situated within the computer apparatus.
Connection ports	These ports allow data to move to and from the computer via peripheral or storage devices and are made to fit

Component	Description
Cards	different types of plug-in devices, including monitor cable, keyboard, mouse, network cable, microphone/speaker/auxiliary input, USB, and printer ports (SCSI or parallel). **Graphics card**: Most computers have a graphics accelerator card slotted in the microprocessor to process image data and output those data to the monitor. If a user intends to create or view three-dimensional images or is an active game user, an enhanced **graphics card** generally must be installed. **Video adapter cards**: Provide video memory, a video processor, and a digital-to-analog converter that works with the processor to output high-quality video images to the monitor. **Sound card**: Converts digital data into an analog signal, which is then outputted to the computer's speakers or headphones. The reverse is also accomplished by inputting a signal from a microphone or other audio-recording equipment, which then converts the analog signal to a digital signal.

Binary System and Storage Bit

A **bit** is the smallest possible chunk of data memory used in computer processing and is depicted as either a 1 or a 0. Bits make up the **binary system** of the computer.

Byte

A **byte** is a chunk of memory that consists of 8 bits and is the best way to indicate computer memory or storage capacity. In modern computers, bytes are described in units of **megabytes (MB)**, **gigabytes (GB)** (1 GB equals 1,000 MB), or **terabytes (TB)** (1 TB equals 1 trillion bytes, or 1,000 GB). **Box 3-2** discusses the various storage capacities.

BOX 3-2 STORAGE CAPACITIES

Dee McGonigle and Kathleen Mastrian

Storage and memory capacities are evolving. In the past few decades, great leaps in data storage have been made. All storage capacity begins with the bit. The files on a computer are stored as binary files. The software that is used translates these binary files into words, numbers, pictures, images, or video. Using this binary code in the binary numbering system, measurement is counted by factors of 2, such as 1, 2, 4, 8, 16, 32, 64, and 128. These multiples of the binary system in computer usage are also prefixed based on the metric system. Therefore, a kilobyte (KB) is actually 2 to the 10th power (or 2^{10}), or 1,024 bytes, but it is typically considered to be 1,000 bytes. That is why you will see 1,024 or multiples of that number, instead of an even 1,000, mentioned at times in relation to kilobytes.

As capabilities soared, so did the ability to save and store what was used and created, and so the megabyte (MB) emerged as a common unit of measure (1 MB is 1,048,576 bytes but roughly equivalent to 1 million bytes). The next leap in computer capacity is a gigabyte (GB) (1 GB is 1,073,741,824 bytes but is generally rounded to 1 billion bytes). Some computing experts are very concerned that valuable bytes are lost when these measurements are rounded, whereas hard-drive manufacturers use the decimal system so that capacity is expressed as an even 1 billion bytes per gigabyte.

Computer capacity has moved into and beyond the range of terabytes, with capacities moving into the range of **petabytes (PB)**, **exabytes (EB)**, **zettabytes (ZB)**, and **yottabytes (YB)**. These terms for storage capacity are defined as follows:

- 1 TB = 1,000 GB
- 1 PB = 1,000,000 GB
- 1 EB = 1,000 PB
- 1 ZB = 1,000 EB
- 1 YB = 1,000 ZB

To put all of this in perspective, Lyman and Varian (2003) described the data powers of 10 as follows:

- 2 KB: A typewritten page
- 2 MB: A high-resolution photograph
- 10 MB: A minute of high-fidelity sound *or* a digital chest X-ray
- 50 MB: A digital mammogram
- 1 GB: A symphony in high-fidelity sound *or* a movie at TV quality
- 1 TB: All the X-ray films in a large, technologically advanced hospital

- 2 PB: The contents of all U.S. academic research libraries
- 5 EB: All words ever spoken by human beings

And we have not even addressed zettabytes (ZB) and yottabytes (YB), so stay tuned.

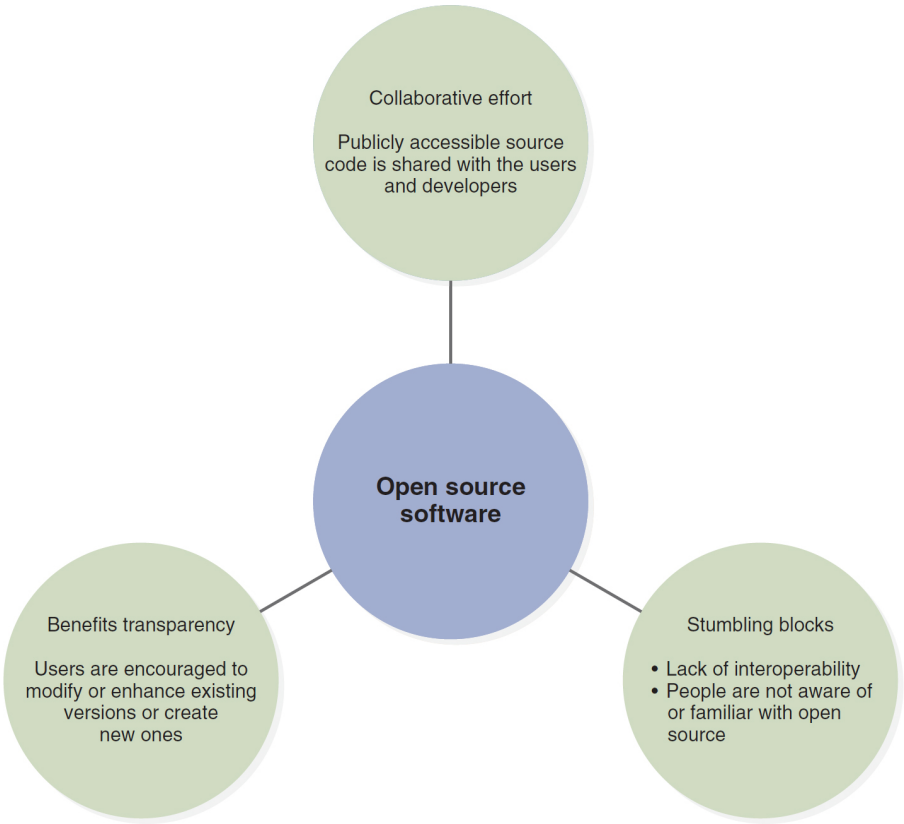
Software

Software comprises the application programs developed to facilitate various user functions, such as writing, artwork, organizing meetings, surfing the internet, and communicating with others. For the purposes of this overview, the various types of software have been divided into four categories: (1) OS software, (2) productivity software, (3) creativity software, and (4) communication software.

User friendliness is a critical condition for effective software adoption. How user friendly the software is to users is based on their perception of how clear the package is to understand and to use. The rapid evolution of hardware mentioned previously has been equally matched by the phenomenal development in software over the past three or four decades (see **Table 3-2** for a brief review of software).

TABLE 3-2 Software

Software	Description
Commercial	Several large commercial software companies, such as Apple, Microsoft, IBM, and Adobe, dominate the market and have done so since the advent of the **personal computer (PC)**. Licensed software has evolved over time; hence, most products have a long version history. Many software packages, such as office suites, are expensive to purchase; in turn, there is a digital divide as far as access and affordability go across societal spheres, especially when viewed from a global perspective.

Software	Description
Open source	The **open source** initiative began in the late 1990s and has become a powerful movement that is changing the software production and consumer market. In addition to commercially available software, a growing number of open source software packages are being developed in all four of the categories addressed in this chapter. The open source movement was begun by developers who wished to offer their creations to others for the good of the community and encouraged them to do the same. Users who modify or contribute to the evolution of open source software are obligated to share their new code, but essentially the software is free to all. Apache OpenOffice, Google Docs, and NeoOffice are examples of open source productivity software (**Figure 3-3**).  **Figure 3-3** Open Source Software

Software	Description
Operating system (OS)	Description The OS is the most important software on any computer. It is the very first program to load upon start-up and is fundamental for the operation of all other software and the computer hardware since it provides a reliable, consistent interface for the software applications to work with the computer's hardware. Examples of commonly used OSs include the Microsoft Windows family, Linux, and Mac OS. An OS must be both powerful and flexible to adapt to the myriad types of software available, which are made by a variety of development companies. New versions of the major OSs are equipped to deal with multiple users and handle multitasking with ease. For example, a user can work on a word processing document while listening for an email-received signal, have an internet browser window open to look for references on the internet as needed, listen to music in the background, and download a file—all at the same time. OS tasks can be described in terms of six basic processes: • Memory management • Device management • Processor management • Storage management • Application interface • **User interface** (usually a **graphical user interface [GUI]**) A GUI (pronounced "gooey") is used by OSs to display a combination of graphics and text, such as icons, drop-down menus, and buttons; it allows one to use input and output devices as well as icons that represent files, programs, actions, and processes. OSs should be convenient to use, easy to learn, reliable, safe, secure, and fast. They should also be easy to design, implement, and maintain while being

Software	Description
	flexible, **compatible**, **portable**, reliable, error-free, **extensible**, and efficient.
Productivity	**Productivity software**, such as an **office suite**, is the type of software most commonly used in the workplace and on personal computers. It typically bundles together word processing, spreadsheet, **database**, presentation, web development, and email programs. The intent of office suites is to provide all the basic programs that office or knowledge workers need to do their work. The bundled programs within the suite are organized to be compatible with one another and designed to look similar to one another for ease of use and provide a powerful array of tools for data manipulation, information gathering, and knowledge generation. Some office suites add other programs, such as database creation software, mathematical editors, and drawing and desktop publishing programs. **Table 3-3** summarizes the application of programs included in some of the popular office suites: Microsoft Office, Apache OpenOffice, and WordPerfect Suite.
Creativity	**Creativity software** includes programs that allow users to draw, paint, render, record music and sound, and incorporate digital video and other multimedia in professional aesthetic ways to share and convey information and knowledge (**Table 3-4**).
Communication	Networking and **communication software** enable users to dialogue, share, and network with other users via email or **instant message (IM)**, by accessing the **World Wide Web (WWW)**, or by engaging in virtual meetings using **conferencing software** (**Table 3-5**).

TABLE 3-3 Productivity: Office Suite Software Features and Examples

Program	Application	Examples

Word processing	Composition, editing, formatting, and producing text documents	Microsoft Word, OpenOffice Writer, KOffice KWord, Corel WordPerfect or Corel Write, Apple Pages, and Apache OpenOffice
Spreadsheets	Grid-based documents in ledger format; organize numbers and text and calculate statistical formulae	Microsoft Excel, OpenOffice Calc, KOffice KSpread, Corel Quattro Pro, Apple Numbers, and Apache OpenOffice
Presentations	Slideshow software, usually used for business or classroom presentations, using text, images, graphs, and media	Microsoft PowerPoint, OpenOffice Impress, KOffice KPresenter, Corel Show, Apple Keynote, and Apache OpenOffice
Databases	Database creation for text and numbers	Microsoft Access (in elite packages), OpenOffice Base, KOffice Kexi, Corel Calculate, Corel Paradox
Email	Integrated **email** program to send and receive electronic mail	Microsoft Outlook, Corel WordPerfect Mail, Mozilla Thunderbird
Drawing	Graphics and diagram drawing	OpenOffice Draw, Corel Presentation Graphics, KOffice Kivio, Karbon, Krita
Math formulas	Insert math equations in word processing and presentation work	OpenOffice Math, KOffice KFormula
Desktop publishing	Page layouts and publication-ready documents	Microsoft Publisher (in elite packages), Apple Pages

TABLE 3-4 Creative Software Features and Examples

Program and Application	Software Examples
Raster graphics programs	
Draw, paint, render, manipulate, and edit images, fonts, and photographs to create pixel-based (dot points) digital art and graphics.	Adobe Photoshop and Fireworks; Ulead PhotoImpact; CorelDRAW, Painter, and PaintShop Pro; GIMP (open source); KOffice; Krita (open source)
Vector graphics programs	
Mathematically rendered geometric modeling is applied through shapes, curves, lines, and points and manipulated for shape, color, and size. Ideal for printing and three-dimensional (3D) modeling.	Adobe Flash, FreeHand, and Illustrator; CorelDRAW and Designer; OpenOffice Draw (open source); Microsoft Visio; Xara Xtreme; KOffice Karbon14 (open source)
Desktop publishing programs	
Page layout and publishing preparation for printed and web documents, such as magazines, journals, books, newsletters, and brochures.	Adobe InDesign, Corel PageMaker, Microsoft Publisher, Scribus (open source), QuarkXPress, Apple Pages (note that many of the graphics programs can also be used for desktop publishing)
Web design programs	
Create, edit, and update webpages using specific codes, such as XML, CSS, HTML, and Java.	Adobe Dreamweaver, Word Press, Microsoft FrontPage, Nvu (open source), W3C's Amaya (open source)
Multimedia programs	
Combine text, audio, images, animation, and video into interactive content for electronic presentation.	Adobe Flash, Microsoft Movie Maker, Apple QuickTime and FinalCut Studio, Corel VideoStudio, Ulead VideoStudio, Real Studio, CamStudio

	(open source), Audacity (open source)

TABLE 3-5 Communication Software Features and Examples

Program and Application	Software Examples
Email client	
Allows user to read, edit, forward, and send email messages to other users via an internet connection. The software can be resident on the computer or accessed via the World Wide Web.	**Resident programs** Microsoft Outlook and Outlook Express, Eudora, Pegasus, Mozilla Thunderbird, Lotus Notes **Web-based programs** Gmail, Yahoo Mail, Hotmail
Internet browsers	
Enables user to access, browse, download, upload, and interact with text, audio, video, and other web-based documents.	Mozilla Firefox, Microsoft Internet Explorer and Edge, Google Chrome, Apple Safari, Opera, microbrowsers (for **mobile** access)
Instant messaging (IM)	
Real-time text messaging between users; can attach images, videos, and other documents via personal computer, cell phone, and handheld devices.	MSN Instant Messenger, Microsoft Live Messenger, Yahoo Messenger, Apple iChat
Conferencing	
Enables user to communicate in a virtual meeting room setting to share work, discussions, or planning using an intranet	Adobe Acrobat Connect, Microsoft Live Meeting or Meeting Space, Microsoft Teams, GoToMeeting,

or internet environment; can exhibit files, video, and screenshots of content.	Meeting Bridge, Free Conference, RainDance, WebEx, Zoom

Acquisition of Data and Information: Input Components

Input devices include keyboard; mouse; joystick (typically used for playing computer games); game controller or pad; web camera (webcam); stylus (often used with tablets or personal digital assistants); image scanner for copying a digital image of a document or picture; touch pad; or other **plug-and-play** input devices, such as a digital camera, digital video recorder (camcorder), **MPEG-1 Audio Layer-3 (MP3)** player, electronic musical instrument, and physiological monitor. These devices are the media used to input text or visual, audio, or multimedia data into the computer system for viewing, listening, manipulating, creating, or editing. The primary input devices on a computer are the keyboard, mouse, touch pad, and touch screen. See **Table 3-6** for a brief overview of the typical input devices.

TABLE 3-6 Typical Input Devices

Input Component	Description
Keyboard	A computer keyboard is very similar to the typewriter keyboards of earlier days and usually serves as the primary input device that enables the user to type words, numbers, and commands into the computer's programs. Typically, standard computer keyboards are organized to facilitate Latin-based languages using a **QWERTY** layout (so named because these letters appear on the first six keys in the first row of letters). Certain keys are used as command keys, particularly the control (CTRL), alternate (Alt), delete (Del), and shift keys, all of which can be used to activate useful

	commands. The escape (ESC) key allows the user to instantly exit a process or program. Some keyboards have a wire and a plug-in, whereas others are **wireless**, or cordless. Touch screen, or virtual, keyboards are incorporated into the touch screens of phones, gaming machines, and tablets, and they are also available through ease-of-access tools on **laptops**.
Mouse	The mouse is the second most commonly used input device. It is manipulated by the user's hand to point, click, and move objects around on the computer screen. A mouse can come in a number of configurations, including a standard mechanical trackball serial mouse, bus mouse, PS/2 mouse, USB-connected mouse, optical lens mouse, cordless mouse, and optomechanical mouse. It has evolved and increased in complexity and capability over time. Most gaming mice have become sophisticated with customizable features, such as programmable macro commands and on-the-fly resolution switching.
Touch pad	A device that senses the pressure of the user's finger along with the movement of the finger on the **touch pad** to control input positioning. It is an alternative to using a mouse.
Touch screen	The **touch screen** is a display used as an input device for interacting with or relating to the display's materials or content. The user can touch or press on the designated display area to respond to, execute, or request information or output.

Processing of Data and Information: Throughput/Processing Components

All the hardware discussed earlier in this chapter is involved in the **throughput**, or **processing**, of input data and the preparation of output data and information. Specific software is used, depending on the application and data involved. One key hardware component, the computer **monitor**, is a unique example of a visible throughput

component; it is the part of the computer that users focus on the most when they are working on a computer. Input data can be visualized and accessed by manipulating the mouse and keyboard input devices, but the monitor is what the user focuses on. The monitor is critical for the efficient rendering or image synthesis so that the data, information, and images can be visualized during this part of the cycle because it facilitates user access and control of the data and information.

Monitor

The monitor is the visual display that serves as the landscape for all interactions between the user and the machine. Some computer monitors also have a touch screen, which can serve as an input device when the user touches specific areas of the screen. Monitors vary in their refresh rate and dot pitch, and both are important for user comfort. The faster the refresh rate, the cleaner and clearer the image on the screen because the monitor refreshes the screen contents more frequently. Similarly, the larger the dot pitch factor, the smaller the dots that make up the screen image, which provides a more detailed display on the monitor and facilitates clarity and ease of viewing.

If equipped with a touch screen, a monitor can also serve as an input device when activated by a stylus or finger pressure. Some users might also consider the monitor to be an output device because access to input and stored documents is often performed via the screen (e.g., reading a document that is stored on the computer or viewable from the internet). As we advance to more engaged computing, larger screens and ultrawide monitors are evolving to provide immersive experiences.

Smartphone displays can be a form of **active-matrix organic light-emitting diode (AMOLED)** or **in-plane switching liquid-crystal display (IPS LCD)**. In the AMOLED type of display, the individual pixels are lit separately (active matrix); the next-generation super AMOLED type of display includes touch sensors.

Dissemination: Output Components

Output devices carry data in a usable form through exit devices in or attached to a computer. Common forms of output include printed documents; audio or video files; physiological summaries; scan results; and saved files on portable disk drives, a flash drive, or an external hard drive. Output devices literally put data and information at the user's fingertips, which can then be used to develop knowledge and even wisdom. The most commonly used output devices include printers, speakers, and portable disk drives.

Printer

Printers are external components that can be attached to a computer enabling users to print a hard copy of documents that are housed on the computer.

Printers are typically all-in-one machines, meaning they can print, scan, fax, and copy. There are printers that can be accessed via the internet using Wi-Fi. There are also three-dimensional (3D) printers that can create a 3D solid object produced layer by layer from a 3D software digital file.

Speakers

All computers have some sort of speaker setup, usually small speakers embedded in the monitor or in the case, or if it is a laptop, close to the keyboard. Often, external speakers are added to a computer system to provide enhanced sound and a more enjoyable listening experience.

What Is the Relationship of Computer Science to Knowledge?

Scholars and researchers understand the effects that computer systems, architecture, applications, and processes have on the potential for knowledge acquisition and development. Users who have access to contemporary computers equipped with full internet access have extensive resources at their fingertips such as entire library collections. Users are also able to contribute to the development of knowledge through the use of productivity, creativity, and communication software and are able to disseminate knowledge on a grand scale with other users. This deluge of information available via computers must be mastered and organized by the user if knowledge is to emerge. Discernment and the ability to critique and filter this information must also be present to facilitate the further development of wisdom.

The development of an understanding of **computer science** principles as they apply to technology used in nursing can facilitate optimal usage of the technology for knowledge development and dissemination in the profession. The maxim that knowledge is power and that the skillful use of computers lies at the heart of this power is a presumption. Once nurses become comfortable with the various technologies, they can shape, refine, and apply them in new and different ways, just as they have always adapted equipment and technologies. Nurses must harness the power of data and information through the use of computer technologies to build knowledge and gain wisdom.

How Does the Computer Support Collaboration and Information Exchange?

Computers can be linked to other computers through networking software and hardware to promote communication, information exchange, work sharing, and collaboration. **Networks** can be

- local or organizationally based, with computers joined together into a **local area network (LAN)**;
- organized on a wider area scope such as a city or distinct geographic area, such as a cable TV network, using a metropolitan area network (MAN) typically comprising several LANs that are interconnected over a dedicated backbone connection; and
- encompassing computers at an even greater distance, such as a country, continent, or even the internet itself, using a **wide area network (WAN)**.

Network interface cards are used to connect a computer and its modem to a network. A **virtual private network (VPN)** provides secure and private connectivity between networks and remote computers or devices using **encryption**, which transforms information or data into a code to prevent unauthorized access.

Networks within health care can manifest in several configurations, including client-focused networks, such as in telenursing, e-health, and client support networks; work-related networks, including virtual work and virtual social networks; and learning and research networks, as in communities of practice. These trends are still evolving in most nursing work environments (and most nurses' personal lives), but they are growing dramatically. We are experiencing one of the greatest upsurges in shared information and our ability to access, exchange, and utilize this information to enhance knowledge.

Virtual social networks are another form of professional network that have expanded phenomenally since the advent of the internet and other computer software and hardware. Nursing-related virtual social networks provide a cyberspace for nurses to make contacts, share information and ideas, and build a sense of community.

Social communication software is used to provide a dynamic virtual environment, and often virtual social networks provide communicative capabilities through posting tools, such as blogs, forums, and wikis; email for sharing ideas on a smaller scale; collaborative areas for interaction and creating and building digital artifacts or planning projects; navigation tools for moving through the virtual network landscape; and profiles to provide a space for each member to disclose personal information with others. Nurses engaged in shift work often find that virtual social networks can provide a sense of connection with other professionals that is available around the clock. Because time is often a factor in any social interchange, virtual communication offers an alternative for practicing nurses. With active participation, the interchanges and shared information and ideas of the network can culminate in valuable social and cultural capital, which is available to all members of that network. Often, nursing virtual social networks are created for the purpose of exchanging ideas on practice issues and best practices; becoming more knowledgeable about new trends, research, and innovations in health care; or participating in advocacy, activist, and educational initiatives.

Through the use of portable disk devices, such as flash drives, as well as web-based and cloud spaces, people can share information, documents, and communications by exchanging files. The World Wide Web has evolved to become a viable and user-friendly way for people to collaborate and exchange information; projects; and other knowledge-based files, such as websites, email, social networking applications, and webinar logs.

Mobile Computing

Mobile computing is a technology that allows human–computer interaction wherever you are by transporting the capability of transmitting data, voice, and video with you, whether you are moving or standing still. A mobile OS is different from a computer's OS in one important way, being designed for mobile use for wireless transmissions. Mobile OSs were created specifically for mobile devices, such as a smartphone, tablet, or other embedded mobile OS. Two of the most popular OSs are Android OS (Google) and iPhone OS, or iOS (Apple). **Wireless mobile computing** refers to mobile computing without the need for wires or cables to connect to a network. The wireless system affords a fixed or portable end point with access to a distributed network. A **distributed network** consists of shared programming and data spread across more than one computer. A mobile computing system provides all the resources of that distributed network to devices that are portable, or that can go anywhere. However, because mobile systems are transported to various locations, they can experience issues within the locality that affect reception. Therefore, mobile and wireless systems actually achieve two different things. **Wi-Fi** is a wireless technology that allows electronic devices (e.g., smartphones, laptops, and tablets) to exchange data over the internet using radio waves by connecting to a Wi-Fi network in the vicinity or locale of the device. A **Wi-Fi hotspot** is a wireless access point that is usually provided in a public location, such as cafés, libraries, hotels, airports, and even grocery stores. Even though these technologies continue to improve, it is important to note that our mobile devices are only as secure as the network that we access and over which we transmit data.

Near field communication (NFC) and **far-field communication** refer to regions of the electromagnetic field around an object. NFC is a wireless and contactless communication technology that makes a device even smarter because it streamlines information transmissions and is the ultimate in connectivity. It

allows the user to wave the smartphone over an NFC-compatible device to send information without having to touch the devices together or complete multiple steps to set up the connection. NFC-compatible devices contain an NFC tag that is passive and operates without a power supply of its own; it is designed to store information and transfer a wide variety of data types to other NFC-enabled devices. The architecture of the NFC tags evolved from **radio-frequency identification (RFID)**. RFID uses radio waves to identify objects or people with encoded microchips. NFC tags are passive devices, and NFC chip technology operates as one part of a wireless link that, when activated by another chip, transfers data between the two devices. There are different types of NFC tags, including labels and wristbands with varying storage capacities and transfer speeds. Mobile computing applications will continue to evolve, and healthcare organizations will continue to meet the **security** challenge while they manage their mobile computing devices and wireless networks as enterprise solutions to meet their strategic plans.

Bandwidth, Broadband, and Mobile Broadband Versus Wireless Broadband

Bandwidth and Broadband

Bandwidth is the measurement in bits, bytes, kilobytes, megabytes, and gigabytes of the data that can be transferred from or to your computer. **Broadband**, or a wide band or range of frequencies, is the minimum speed at which your connection will transfer information. Tundlam (2015) developed a simple analogy using roads and traffic to explain the difference between bandwidth and broadband. Bandwidth would be related to the "speed limit of the highway. Assuming each car is a fixed size, the number of cars going through a highway is nothing but the average speed of the cars on the highway. Cars per second would be the unit." Tundlam likened broadband to the "highway itself. A fast lane that allows cars to go at a speed higher than on most other roads. Antonym is narrowband, analogous to a city road, much less speed and capacity."

Mobile Broadband Versus Wireless Broadband

The difference between mobile and wireless broadband depends on the limitations of accessing the internet and the method of access.

Both wireless and mobile broadband are fast internet access technologies, but only mobile broadband permits end users to access the internet from different locations without restrictions. Some mobile broadband technologies are included in wireless broadband access methods because of the inaccessibility of wired connectivity.

Cloud Computing

Cloud computing has web browser–based login-accessible data, software, and hardware that can be accessed and used. Using the cloud, systems can be linked together and costs reduced (**Figure 3-4**). According to Griffith (2020), **cloud computing** refers to storing and accessing data and programs over the internet, instead of on a computer's hard drive. "[T]he 'cloud' is just a metaphor for the internet" (para. 3). According to Vennam (2020), the definition of cloud computing is as follows:

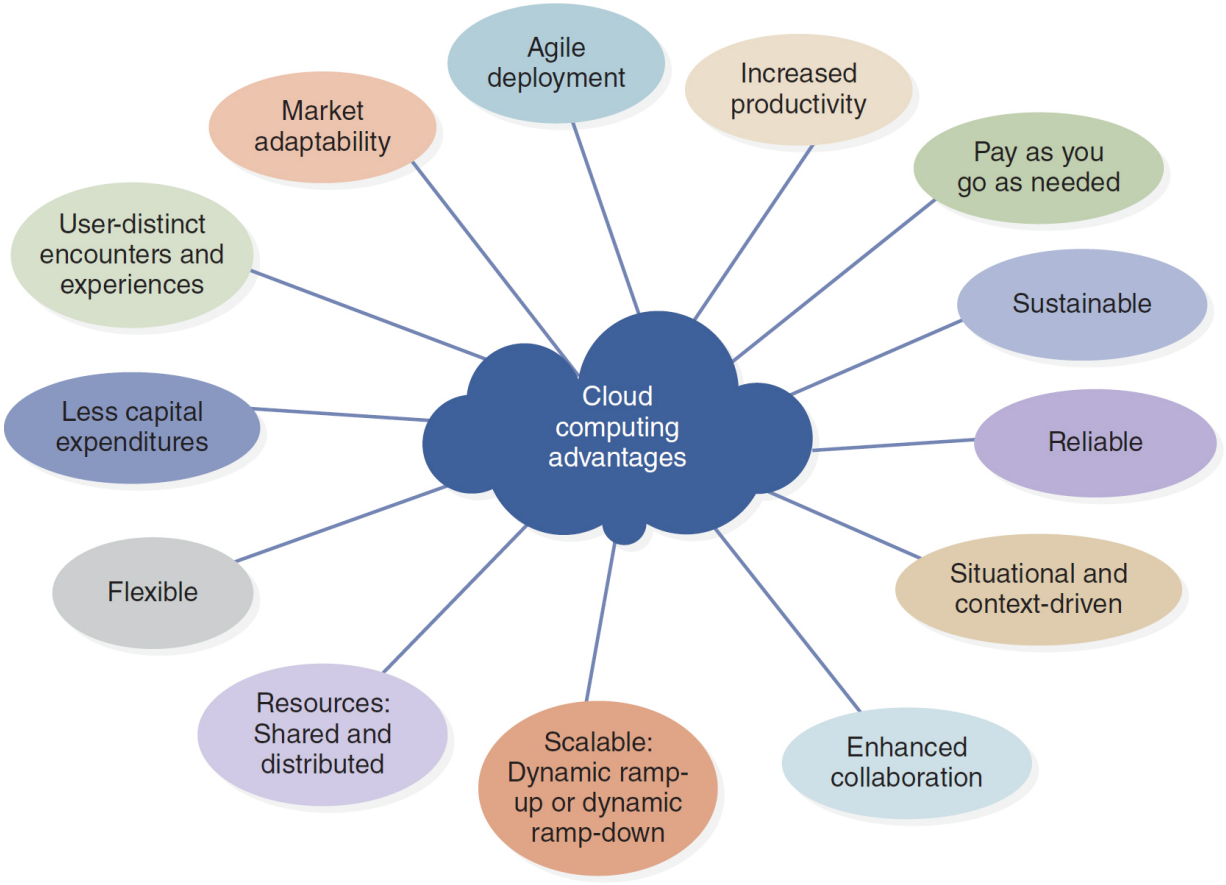


Figure 3-4 Cloud Computing

Description

> *[It] is on-demand access, via the internet, to computing resources—applications, servers (physical servers and virtual servers), data storage, development tools, networking capabilities, and more—hosted at a remote data center managed by a cloud services provider (or CSP).* (para. 1)

The CSP is a pay as you go service, where the user is billed based on the resources they use. Robust technological capabilities such as artificial intelligence (AI) and blockchain technology are utilized to enhance security.

As we explore web-based apps and computing over the internet, we are cloud computing. Griffith (2020) described common examples of cloud computing that you might be using right now: Google Drive, Microsoft Office Online, Microsoft OneDrive, Apple iCloud, Amazon Cloud Drive, Box, Dropbox, and SugarSync. And then there's cloud hardware. The primary example of a device that is completely cloud centric is the **Chromebook**, which is a laptop that has just enough local storage and power to run the Chrome OS, which essentially turns the Google Chrome web browser into an operating system. The Chromebook moves cloud computing to the next level because applications and games accessed on the computer are executing on the cloud. Therefore, the Chromebook is an example of where personal computing might evolve—devices that have a web browser reaching out to online applications and services with a small number of local applications and minimal storage capabilities. In the cloud computing model, users must rely heavily on their internet providers for connectivity, speed, and bandwidth. The speed relates to how fast users can upload and download, and the bandwidth relates to how much data can be uploaded and downloaded. The speed and bandwidth issues could hinder mass appeal of the Chromebook. **Cloud storage** is the housing of data that is provided by networked online servers, which are typically located outside of the institutions whose data are being stored.

There are also services other than those already discussed that are based in the cloud and that are mainly business related: **software as a service (SaaS)**, **platform as a service (PaaS)**, and **infrastructure as a service (IaaS)** (**Figure 3-5**). SaaS, such

as Salesforce.com, refers to cloud-based applications with the following benefits: quick start in using innovative or specific business apps that are scalable to a company's needs, any connected computer can access the apps and data, and data are not lost if a hard drive crashes because the data are stored in the cloud (Griffith, 2020; Vennam, 2020). PaaS provides everything needed to support the cloud application's building and delivery, which enables users to rapidly develop and launch custom web applications to the cloud (Griffith, 2020; Vennam, 2020). IaaS, such as Amazon, Microsoft, Google, and Rackspace, provide a rentable backbone to companies, enabling the scalable, on-demand infrastructure they need to support their dynamic workloads. Users pay for only what they use, and they do not have to invest in hardware, such as networks, storage, and data center space (Griffith, 2020; Vennam, 2020). Users can access and receive services from Netflix and Pinterest because they are customers of Amazon's cloud services. According to Precedence Research (2023), "The global cloud computing market size was valued at USD 446.51 billion in 2022 and is expected to hit USD 1,614.10 billion by 2030" (para. 1).

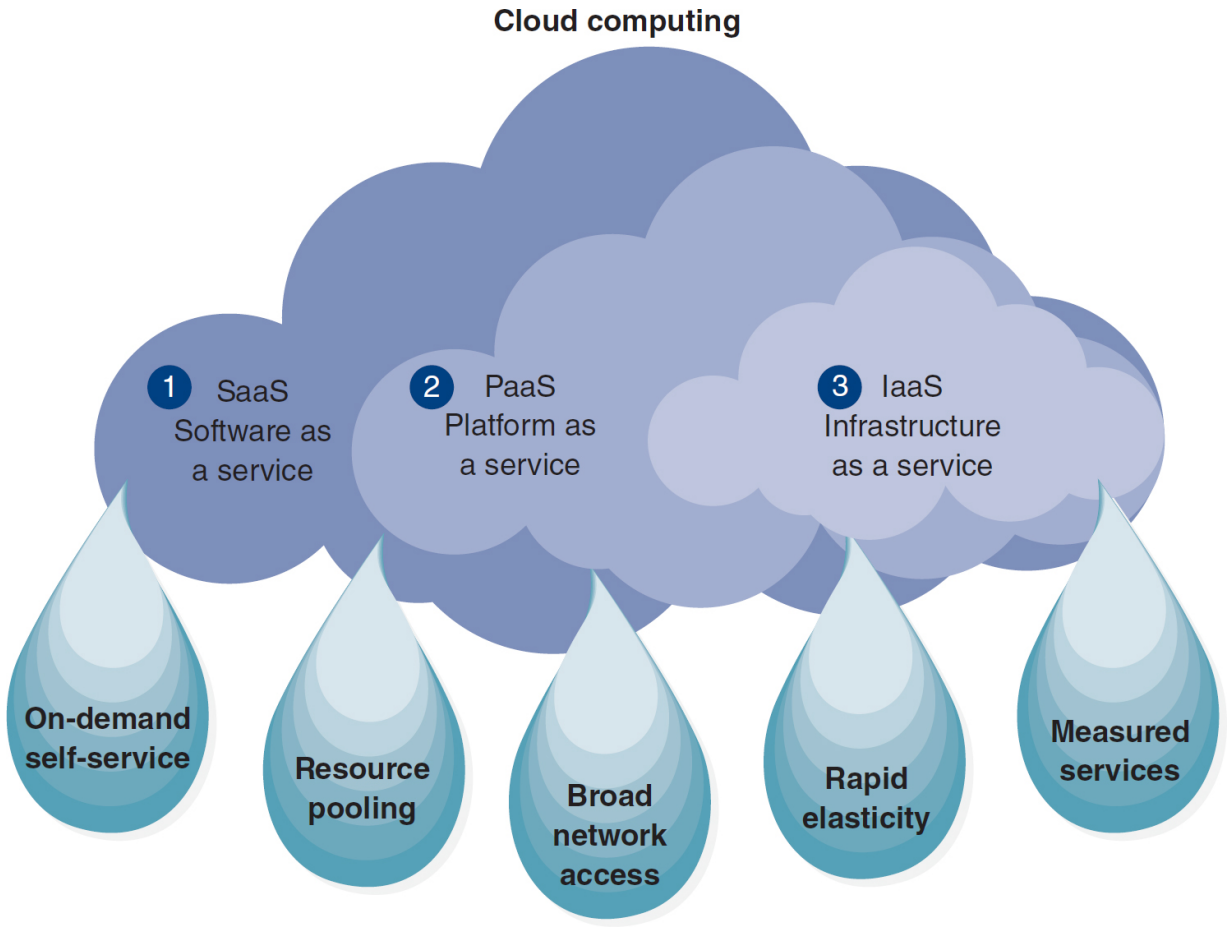


Figure 3-5 Software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS)

Description

Cloud computing is internet computing, and it has the same pitfalls and benefits as using the internet. Some people are not sold on the claims that it is totally reliable, safe, and secure. Others believe it is a more environmentally friendly option because it uses fewer resources and less energy compared to other internet services, and yet many people can share efficiently managed, centralized cloud-based systems (Woodford, 2022). One of the driving forces behind the initiation of cloud computing was the need for affordable, scalable resources. As with anything on the internet, these resources can be shared or privately held. Cloud computing will continue to grow as long as there is a demand for it and it can meet the scalability requirements while maintaining secure, reliable

spaces. Splunk (2022) stated that one of the top five security, incident, and event management (SIEM) priority trends to watch will continue to be cloud and app security. According to Doyle (2020), "Device-as-a-Service (DaaS) means medical teams can benefit from the more flexible provision of IT [information technology] equipment such as **desktops**, laptops and other mobile devices" (para. 1). Reflect on DaaS as one of the solutions in **Case Study 3-1**. What are the advantages of incorporating DaaS as one of the solutions in this health system?

CASE STUDY 3-1

Hospital system: Mid-Cheshire Hospitals NHS Foundation Trust

- 540 beds and community health services
- 4,500 staff across three hospital sites in northwest England

Problem: Aging infrastructure, including desktop devices that were over 10 years old, which was having a negative effect on thousands of its staff members' productivity and stressing its internal information technology help desk.

Solution from CDW: Formulating a compelling business case and implementing the following:

- Microsoft Office 365 to improve user experience; security, including email encryption; and support collaboration.
- Microsoft SharePoint platform for user collaboration.
- Windows 10 and new password reset tool to decrease help desk calls.
- Unable to replace all devices at once, CDW developed a business case to replace those devices over 10 years old; a DaaS solution delivered by CDW established a new 5-year refresh cycle.

Outcome: Infrastructure renewal is benefiting from CDW's CloudPlan service while CDW prepares for migration to Microsoft Azure* in the near future. CDW is also rolling out Cisco networking technology to enable free Wi-Fi for patients.

*Microsoft described Azure as an "ever-expanding set of cloud services" (https://azure.microsoft.com/en-us/overview/what-is-azure). In the healthcare sector, McKesson, one of the oldest and largest healthcare companies, serving more than 50% of U.S. hospitals, chose Azure (https://cloud.netapp.com/blog/azure-cvo-blg-azure-case-studies-with-cloud-volumes-ontap). McKesson needed help to meet the infrastructure needs of their clients (https://cloud.netapp.com/hubfs/success-stories/CS-McKesson.pdf, para. 1).

CDW. (n.d.). *Case study: CDW helps Mid-Cheshire NHS Trust improve patient care by replacing ageing IT infrastructure.* www.uk.cdw.com/about/case-studies/mid-cheshire-nhs-trust

Realizing the benefits of using cloud computing is critical in health care as we seek to blend big data analytics with evidence-based practice to improve patient care. In an ideal world, nurses must be able to interact with computer technologies effectively to enhance patient care. They would be able to understand computer science and know how to harness its capabilities to benefit the profession and ultimately their patients.

Looking to the Future

The use of the cloud will only continue to expand. The market for **wearable technology**, which comprises small handheld and portable computer systems and high-quality voice-activated inventions, will further facilitate the use of computers in nursing practice and professional development. The field of computer science will continue to contribute to the evolving art and science of nursing informatics. New trends promise to bring wide-ranging and (it is hoped) positive changes to the practice of nursing. Computers and other technologies have the potential to support a more client-oriented healthcare system in which clients truly become active participants in their own healthcare planning and decisions. Mobile health technology, telenursing, sophisticated electronic health records, and next-generation technology are predicted to contribute to high-quality nursing care and consultation within healthcare settings, including patients' homes and communities.

Computers are becoming more powerful and compact, which are factors that will contribute to the development of several technological initiatives that are currently evolving, such as quantum computing. Some of these initiatives are described here. These predicted innovations are only some of the many computer and technological applications being developed. As nurses gain proficiency in capitalizing on the creative, time-saving, and interactive capabilities emerging from information technology research, the field of nursing informatics will grow in similar proportions.

Quantum Computing

Quantum bits (qubits) are three-dimensional arrays of atoms in quantum states. A quantum computer is a proposed machine that is not based on the binary system but instead performs calculations based on the behavior of subatomic particles, or qubits. It is

estimated that with **quantum computing**, we will be able to execute **millions of instructions per second (MIPS)** due to the qubits existing in more than one state at a time, or having the ability to simultaneously execute and process. According to Kennedy (2016), "the era of quantum computers is one step closer" (para. 1) due to the creation of qubits by David Weiss's (a professor of physics at Penn State University) research team.

Voice-Activated Communicators

Voice-activated communicators are already on the market, with new iterations being developed by a variety of companies, including Vocera Communications. Vocera (2019) developed the Vocera B3000n Communication Badge. This badge is a wearable, one-to-many, two-way, voice-controlled communication device. This device uses intuitive, simple commands to facilitate responses and communication permitting nurses to use wireless, hands-free devices to communicate with one another and to record data. Such technology is becoming a user-friendly and cost-effective way to increase clinical productivity.

Game and Simulation Technology

Game and simulation technology is offering immersive, realistic, innovative ways to teach content in general, including healthcare informatics concepts and skills. The same technology that powers video games is being used to create dynamic educational interfaces to help students learn about pathophysiology, care guidelines, and a host of other topics. Such applications are also valuable for client education and health promotion materials. The "serious games" industry is growing now that video game producers are looking beyond mere entertainment to address public and private policy; management; and leadership issues and topics, including those related to health care.

Virtual Reality and the Metaverse

VR is influencing and will continue to influence healthcare education and professional development. VR is a three-dimensional, computer-generated "world" in which a person (with the right equipment) can move about and interact as if they were actually in a physical location. The person's senses are immersed in this VR world using special gadgetry, such as **head-mounted displays (HMDs)**, data gloves, joysticks, and other hand tools. Oculus Quest has become Meta Quest (www.meta.com/quest). The **metaverse** is an immersive world where our interactions are facilitated by the realities (virtual, augmented, and mixed), and we can move seamlessly from reality through VRs while we engage in our professional and personal lives. Headsets continue to evolve, and more are entering the market with greater capabilities and lighter weights and designs that will increase the amount of time people can wear them comfortably as the metaverse expands its reach into our personal and professional lives.

Mobile Devices

Mobile devices will be increasingly used by nurses, both at the point of care and in planning, documenting, interacting with the interprofessional healthcare team, and researching. Nurses will also be using such powerful wearable technologies as nano-based diagnostic sensors in their personal lives and will be generating their own data streams and receiving data from the wearable and mobile devices their patients use.

Mobile health (mHealth) is the use of mobile technologies, including mobile phones (and, increasingly, internet-enabled, wireless-connected smartphones), tablet computers and subnotebook microcomputers, remote diagnostic and monitoring devices, and global positioning system (GPS)/geographic information system (GIS) mapping equipment. As society becomes more mobile, people's medical, public health, and self-care health access and

needs can be met with a set of apps, devices, and connections supported by their mobile devices.

Truly, data are at our fingertips.

Summary

The field of computer science is one of the fastest-growing disciplines. Astonishing innovations in computer hardware, software, and architecture have occurred over the past few decades, and there are no indications that this trend will come to a halt any time soon. Computers have increased in speed, accuracy, and efficiency yet now cost less and have reduced physical size compared to their forebears. These trends are predicted to continue. Current computer hardware and software serve as vital and valuable tools for both nurses and patients to engage in on-screen and online activities that provide rich access to data and information. Productivity, creativity, and communication software tools also enable nurses to work with computers to further foster knowledge acquisition and development. Wide access to vast stores of information and knowledge shared by others facilitates the emergence of wisdom in users, which can then be applied to nursing in meaningful and creative ways. It is imperative that nurses exploit the potential of the metaverse and become discerning yet skillful users of computer technology to apply the principles of nursing informatics to their practice to improve patient care and to contribute to the profession's ever-growing body of knowledge.

THOUGHT-PROVOKING QUESTIONS

1. How can knowledge of computer hardware and software help nurses to participate in information technology adoption decisions in the practice area?
2. How can new computer software help nurses engage in professional development, collaboration, and knowledge dissemination activities at their own pace and leisure?

Working Wisdom

Since the beginning of the profession, nurses have applied their ingenuity, resourcefulness, and professional awareness of what works to adapt technology and objects to support nursing care, usually with the intention of promoting efficiency but also in support of client comfort and healing. This resourcefulness could also be applied effectively to the adaptation of information technology within the care environment, to ensure that the technology truly does serve patients, nurses, and the rest of the interprofessional team.

Consider this question: How can you develop competency in using the various computer hardware and software not only to promote efficient, high-quality nursing care and to develop yourself professionally but also to further the development of the profession's body of knowledge?

Application Scenario

Dan P. has just been accepted into the nursing informatics graduate program. In the past, he has used his 8-year-old laptop to surf the World Wide Web, exchange email with friends, and play computer games. Now, however, Dan realizes that the computer is a vital tool for his academic success, and he has saved up enough money to purchase a new laptop computer and the necessary accessories he needs to be successful. He knows that his program will entail VR and that the university has launched their public metaverse space. What questions should he ask of his nursing advisor before he decides on the laptop he should purchase? Dan reached out to his nursing advisor, Dr. Smythely, and she sent Dan a list of general university and program-specific technical requirements needed for his success (see **Box 3-3**).

BOX 3-3 UNIVERSITY AND PROGRAM-SPECIFIC TECHNICAL REQUIREMENTS

UNIVERSITY GENERAL TECHNICAL REQUIREMENTS

These requirements are designed to ensure your success. Please make sure that you are able to meet them, or consult with your student advisor or student support liaison.

As a student, you should be proficient using

- email,
- internet, and
- productivity software.

GENERAL SUGGESTED REQUIREMENTS*

Laptop is required but a newer tablet (3 years old or less) and newer smartphone (3 years old or less) might be able to be used based on specific course requirements/needs.

SUGGESTED SETUP*

- Internet access is required and broadband is highly recommended.
- Windows Vista/7 or Mac OS X with virtualization software (such as Parallels with Windows OS)
- 2 GB of RAM minimum
- 40 GB hard drive
- Speakers connected to the computer
- Headphone connected to the computer
- All-in-one inkjet or laser printer
- Scanner or scanning application for mobile devices
- Portable media (thumb drive)

SOFTWARE REQUIREMENTS

- Required web browser: Google Chrome in its most current version
- Microsoft Office
- Adobe
  - Reader version 10.1 or higher
  - Flash Player version 11.7 or higher
- Apple QuickTime version 7.7 or higher
- Windows Media Player version 11 or higher
- Antivirus software: Most current version of McAfee is suggested, but you can also use the most current version of Norton. This software must be installed, running, and kept current.

ADDITIONAL TECHNOLOGY REQUIREMENTS

Specific programs or courses might require additional technologies that are not addressed in these general requirements.

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*These are the general requirements for the university, but you must consult the software/hardware requirements within your specific program of study with a faculty member, student advisor, or student support liaison. Please note that these recommendations and requirements may change as technology evolves, and changes could also vary from course to course throughout your program of study.

NURSING INFORMATICS GRADUATE NURSING PROGRAM

SPECIFIC TECHNICAL REQUIREMENTS IN ADDITION TO THE GENERAL REQUIREMENTS*

Laptop

MAC Minimum Requirements

- Operating system: Mojave at a minimum; Big Sur would be maximum
- Processor: Intel i5 at least 2.0 GHZ
- Memory: 8 GB RAM or more
- Storage: 9 GB available space
- Graphics card: Dedicated GPU with minimum AMD Radeon Pro 560 4GB
- 2016 or newer hardware
- Microphone and webcam access

Windows PC Minimum Requirements

- Operating system: Windows 10 or newer
- Processor: Intel i5
- Memory: 8 GB RAM or more
- Storage: 9 GB available space
- Graphics card: Nvidia GeForce GTX 970
- 2016 or newer hardware
- Microphone and webcam access

Bandwidth Requirements

Minimum bandwidth:

- 50 Kbps download per learner in the classroom, plus 16 Kbps per open mic learner (1 kbps = 0.001 Mbps)
- 200 Kbps upload (for your video feed) plus 900 Kbps to share your screen

Browser

- Updated Chrome or Edge browser

Head-Mounted Display (VR Headset)

- Meta Quest Pro or Oculus Quest 2 or newer models if available
- Pico 4 or Pico Neo 3
- VIVE Flow or VIVE Focus 3

Apple iPhone 8 or Higher/iPad Minimum System Requirements

- Operating system: iOS 13.0
- Processor: A11 chip or higher
- Memory: 2 GB RAM
- Storage: 5 GB available space

ANDROID SMARTPHONE OR TABLET MINIMUM SYSTEM REQUIREMENTS

- Operating system: Android 7.1.1
- Processor: Qualcomm Snapdragon 835
- Memory: 4 GB RAM
- Storage: 5 GB available space

In addition to these specific technical requirements, you must meet the general requirements.

After completing this chapter, how would you answer the following questions?

1. Dan is set on purchasing a new laptop. Where is his money best spent and why? Would it be better to get the most memory, the fastest processor, the most storage, or the latest operating system?
2. Dan is excited about VR but does not have a clue about which HMD would be best let alone how much they cost. Since he does not know anything about the headsets, what should he do to make an informed decision?
3. Would you tell Dan to evaluate his internet speed and connectivity? How would you explain the importance of the terms *broadband* and *bandwidth*?

What else would you discuss with Dan before he chooses his laptop and HMD if he still wants to learn more about computers? You recommend that he review the following information: Brant (2023) and Burek (2023).

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CHAPTER 4

Introduction to Cognitive Science and Cognitive Informatics

OBJECTIVES

1. Describe cognitive science.
2. Assess how the human mind processes and generates information and knowledge.
3. Explore cognitive informatics.
4. Examine artificial intelligence and its relationship to cognitive science and computer science.

KEY TERMS

- artificial intelligence (AI)
- augmented intelligence
- brain
- cognitive informatics (CI)
- cognitive science
- computer science
- connectionism
- decision-making
- epistemology
- human mental workload (MWL)
- intelligence

- intuition
- knowledge
- logic
- machine learning (ML)
- memory
- mind
- natural language processing (NLP)
- neuroscience
- perception
- problem-solving
- psychology
- reasoning
- wisdom

Introduction

Cognitive science is the fourth of the four basic building blocks used to understand informatics (**Figure 4-1**). The *Building Blocks of Nursing Informatics* section began by examining nursing science, information science, and **computer science** and by considering how each science relates to and helps the reader understand informatics. This chapter explores the critical aspects of cognitive science and how it supports cognitive informatics (CI) and **artificial intelligence (AI)**.

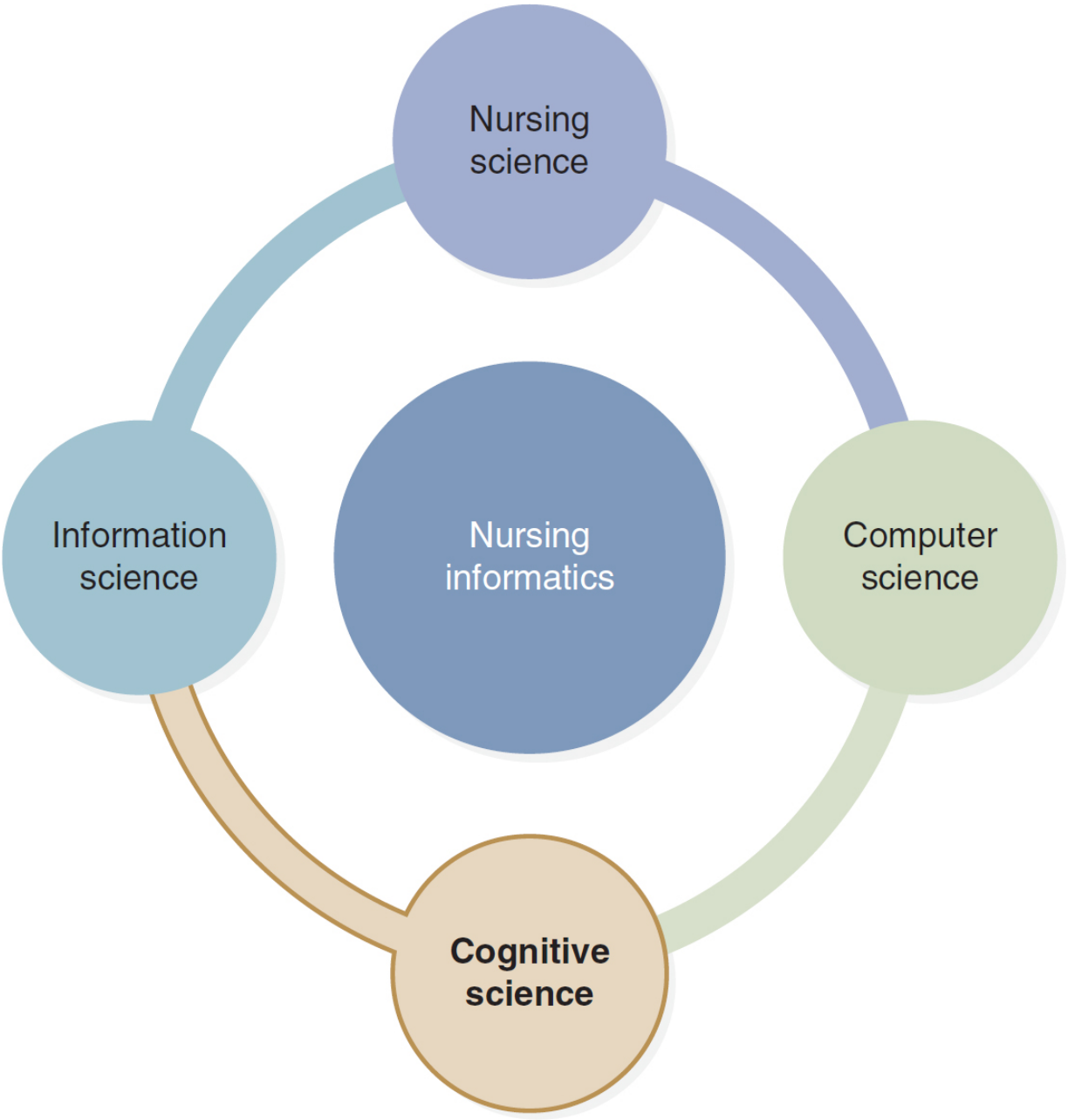


Figure 4-1 Building Blocks of Nursing Informatics

Throughout the centuries, cognitive science has intrigued philosophers and educators alike. Beginning in Greece, the ancient philosophers sought to comprehend how the mind works and the nature of knowledge. This age-old quest to unravel the processes inherent in the working **brain** has been undertaken by some of the greatest minds in history. However, it was only about 50 years ago

that computer operations and actions were linked to cognitive science, meaning theories of the **mind**, intellect, or brain. This association led to the expansion of cognitive science to examine the complete array of cognitive processes, from lower-level perceptions to higher-level critical thinking, logical analysis, and **reasoning**.

The focus of this chapter is the impact of cognitive science on nursing informatics (NI). This section provides the reader with an introduction and overview of cognitive science; the nature of knowledge, wisdom, and AI as they apply to the Foundation of Knowledge model; and NI. The applications to NI include **problem-solving**, decision support systems, usability issues, user-centered interfaces and systems, and the development and use of terminologies.

Cognitive Science

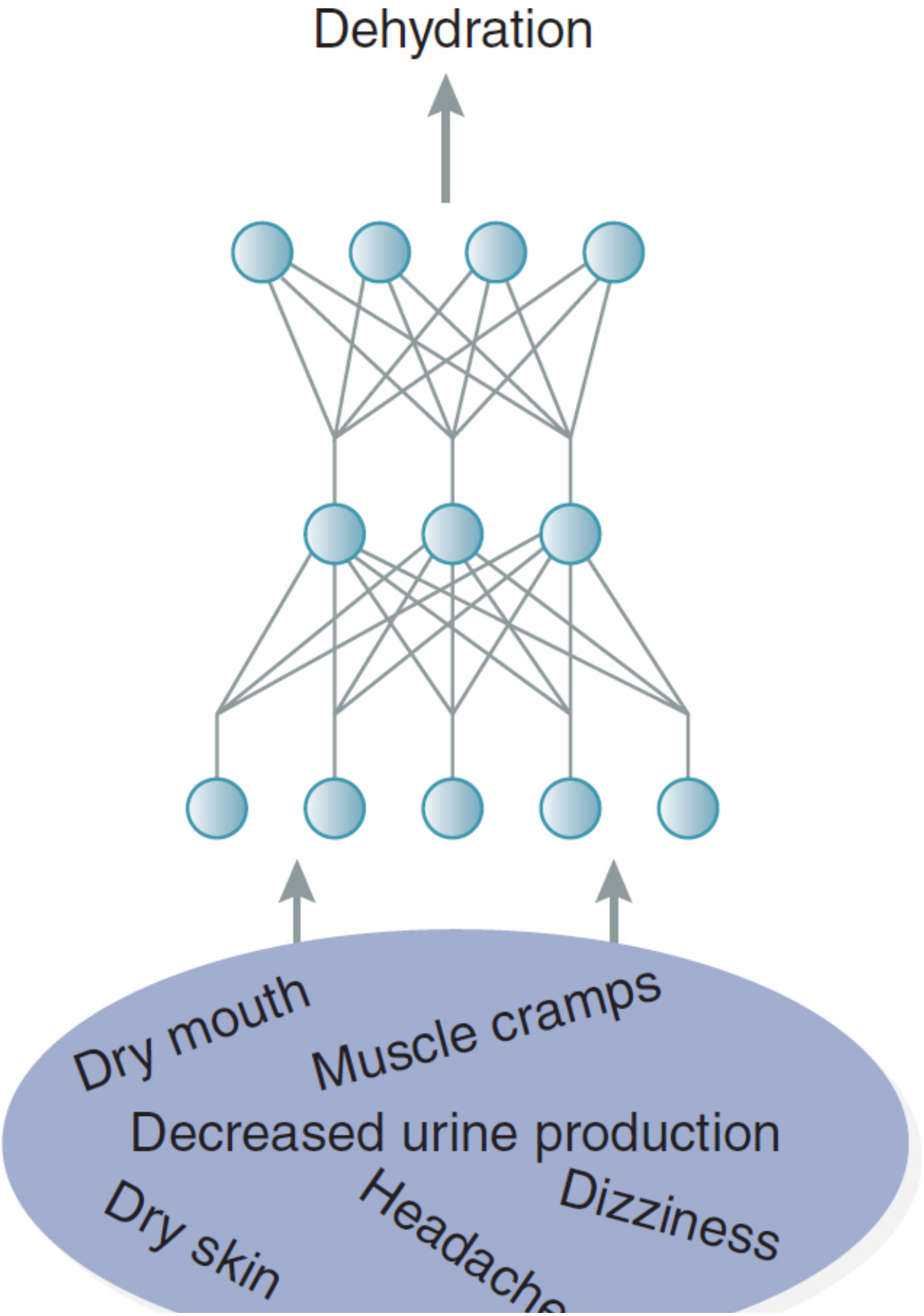
The interdisciplinary field of **cognitive science** studies the mind, **intelligence**, and behavior from an information-processing perspective. H. Christopher Longuet-Higgins originated the term *cognitive science* in his 1973 commentary on the Lighthill report, which pertained to the state of AI research at that time. The Cognitive Science Society and the *Cognitive Science Journal* date back to 1980. The interdisciplinary base of cognitive science arises from **psychology**, philosophy, **neuroscience**, computer science, linguistics, biology, and physics. Its focus covers **memory**, attention, perception, reasoning, language, mental ability, and computational models of cognitive processes. The science explores the nature of the mind, knowledge representation, language, problem-solving, **decision-making**, and the social factors influencing the design and use of technology. Simply put, cognitive science is the study of the mind and how information is processed in the mind. As described in the *Stanford Encyclopedia of Philosophy* (Thagard, 2023):

> *The central hypothesis of cognitive science is that thinking can best be understood in terms of representational structures in the mind and computational procedures that operate on those structures. While there is much disagreement about the nature of the representations and computations that constitute thinking, the central hypothesis is general enough to encompass the current range of thinking in cognitive science, including connectionist theories which model thinking using artificial neural networks.* (para. 109)

Connectionism is a component of cognitive science that uses computer modeling through artificial neural networks to explain human intellectual abilities. Neural networks can be thought of as interconnected simple processing devices or simplified models of the brain and nervous system that consist of a considerable number of elements or units (i.e., analogs of neurons) linked together in a pattern of connections (i.e., analogs of synapses). A neural network that models the entire nervous system would have three types of

units: (1) input units (i.e., analogs of sensory neurons), which receive information to be processed; (2) hidden units (i.e., analogs to all the other neurons, not sensory or motor), which work in between input and output units; and (3) output units (i.e., analogs of motor neurons), where the outcomes, or results of the processing, are found.

Connectionism (**Figure 4-2**) is rooted in how computation occurs in the brain and nervous system, or biological neural networks. On their own, single neurons have minimal computational capacity. When interconnected with other neurons, however, they have immense computational power. The connectionism system learns by modifying the connections linking the neurons. Artificial neural networks are unique computer programs designed to simulate their biological analogs, the neurons of the brain.


Dehydration
Dry mouth
Muscle cramps
Decreased urine production
Dizziness
Headache
Dry skin

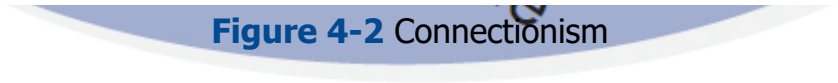


Figure 4-2 Connectionism

The mind is frequently compared to a computer, and experts in computer science strive to understand how the mind processes data and information. In contrast, experts in cognitive science model human thinking using artificial networks provided by computers, an endeavor sometimes referred to as AI. How does the mind process all of the inputs received? Which items and in which ways are things stored or placed into memory, accessed, augmented, changed, reconfigured, and restored? Cognitive science provides the scaffolding for the analysis and modeling of complicated, multifaceted human performance and has a tremendous effect on the issues affecting informatics.

The end user is the focus of this activity because the concern is with enhancing performance in the workplace; in nursing, the end user could be the actual clinician in the clinical setting, and cognitive science can enhance the integration and implementation of the technologies being designed to facilitate this knowledge worker, with the ultimate goal of improving patient care delivery. Technologies change rapidly, and this evolution must be harnessed for the clinician at the bedside. To do this at all levels of nursing practice, one must understand the nature of knowledge, the information and knowledge needed, and the means by which the nurse processes this information and knowledge in the situational context.

Sources of Knowledge

Just as philosophers have questioned the nature of knowledge, so too have they strived to determine how knowledge arises because the origins of knowledge can help us understand its nature. How do people come to know what they know about themselves, others, and their world? There are many viewpoints on this issue, both scientific and nonscientific.

Three sources of **knowledge** have been identified: (1) instinct, (2) reason, and (3) intuition. Instinct is when one reacts without reason, such as when a car is heading toward a pedestrian and they jump out of the way without thinking. Instinct is found in both humans and animals, whereas reason and intuition are found only in humans. Reason "[c]ollects facts, generalizes, reasons out from cause to effect, from effect to cause, from premises to conclusions, from propositions to proofs" (Sivananda, 2017, para. 4). **Intuition** is a way of acquiring knowledge that cannot be obtained by inference, deduction, observation, reason, analysis, or experience. Intuition was described by Aristotle as "[a] leap of understanding, a grasping of a larger concept unreachable by other intellectual means, yet fundamentally an intellectual process" (Shallcross & Sisk, n.d.).

Some believe that knowledge is acquired through perception and logic. **Perception** is the process of acquiring knowledge about the environment or situation by obtaining, interpreting, selecting, and organizing sensory information from seeing, hearing, touching, tasting, and smelling. **Logic** is a discipline that relies on reasoned action or drawing inferences or conclusions based on premises or what you know from finding new data and information by analyzing and synthesizing if other known data and information are true. Acquiring knowledge through logic requires reasoned action to make valid inferences.

The sources of knowledge provide a variety of inputs, throughputs, and outputs through which knowledge is processed. No matter how you believe knowledge is acquired, it is important to be

able to explain or describe those beliefs, communicate those thoughts, enhance shared understanding, and discover the nature of knowledge.

Nature of Knowledge

Epistemology is the study of the nature and origin of knowledge—that is, what it means to know. Everyone has a conception of what it means to know based on their own perceptions, education, and experiences; knowledge is a part of life that continues to grow with the person. Thus, a definition of knowledge is somewhat difficult to agree on because it reflects the viewpoints, beliefs, and understandings of the person or group defining it. Some people believe that knowledge is part of a sequential learning process that resembles a pyramid, with data on the bottom, rising to information, then knowledge, and finally wisdom. Others believe that knowledge emerges from interactions and experience with the environment, and still others think that it is religiously or culturally bound. Knowledge acquisition is thought to be an internal process derived through thinking and cognition or an external process from senses, observations, studies, and interactions. Descartes's important premise "called 'the way of ideas' represents the attempt in epistemology to provide a foundation for our knowledge of the external world (as well as our knowledge of the past and of other minds) in the mental experiences of the individual" (Martinich & Stroll, 2023, para. 4).

For the purpose of this text, knowledge is defined as the awareness and understanding of a set of information and ways that information can be made useful to support a specific task or arrive at a decision. It abounds with others' thoughts and information or consists of information that is synthesized so that relationships are identified and formalized.

How Knowledge and Wisdom Are Used in Decision-Making

The reason for collecting and building data, information, and knowledge is to be able to make informed, judicious, prudent, and intelligent decisions. When you consider the nature of knowledge and its applications, you must also examine the concept of wisdom. **Wisdom** has been defined in numerous ways:

- Knowledge applied in a practical way or translated into actions
- The use of knowledge and experience to heighten common sense and insight to exercise sound judgment in practical matters
- The highest form of common sense resulting from accumulated knowledge or erudition (i.e., deep, thorough learning) or enlightenment (i.e., education that results in understanding and the dissemination of knowledge)
- The ability to apply valuable and viable knowledge, experience, understanding, and insight while being prudent and sensible
- Focused on our own minds
- The synthesis of our experience, insight, understanding, and knowledge
- The appropriate use of knowledge to solve human problems

In essence, wisdom entails knowing when and how to apply knowledge. The decision-making process revolves around knowledge and wisdom. It is through efforts to understand the nature of knowledge and its evolution to wisdom that one can conceive of, build, and implement informatics tools that enhance and mimic the mind's processes to facilitate decision-making and job performance.

Cognitive Informatics

Wang (2003) described **cognitive informatics (CI)** as an emerging transdisciplinary field of study that bridges the gap in understanding regarding how information is processed in the mind and in the computer. Computing and informatics theories can be applied to help elucidate the information processing of the brain, and cognitive and neurological sciences can likewise be applied to build better and more efficient computer processing systems. Wang suggested that the common issue among the human knowledge sciences is the drive to develop an understanding of natural intelligence and human problem-solving.

Patel et al. (2014) defined CI as "the multidisciplinary study of cognition, information and computational sciences that investigates all facets of human computing including design and computer-mediated intelligent action, thus is strongly grounded in methods and theories from cognitive science" (para. 1). CI helps to bridge this gap by systematically exploring the mechanisms of the brain and mind and specifically how information is acquired, represented, remembered, retrieved, generated, and communicated. This dawning of understanding can then be applied and modeled in AI situations, which will then result in more efficient computing applications.

Wang (2003) explained further:

> *Cognitive informatics attempts to solve problems in two connected areas in a bidirectional and multidisciplinary approach. In one direction, CI uses informatics and computing techniques to investigate cognitive science problems, such as memory, learning, and reasoning; in the other direction, CI uses cognitive theories to investigate the problems in informatics, computing, and software engineering.* (p. 120)

Principles of cognitive informatics and an understanding of how humans interact with computers can be used to build information technology (IT) systems that better meet the needs of users (**Figure 4-3**). If a system is too complex or taxing for users, they

are likely to resist its use. The National Center for Cognitive Informatics and Decision Making in Healthcare (NCCD) is funded by the Office of the National Coordinator for Health IT (ONC) under the Strategic Health IT Advanced Research Projects (SHARP) program. The NCCD was established to respond to the cognitive challenges in health IT and to "bring together a collaborative, interdisciplinary team of researchers across the nation with the highest level of expertise in patient centered cognitive support research" (SHARP, 2010, p. 6). Similarly, Longo (2015) emphasized **human mental workload (MWL)** as a key component in effective system design (**Figure 4-4**). He stated the following:

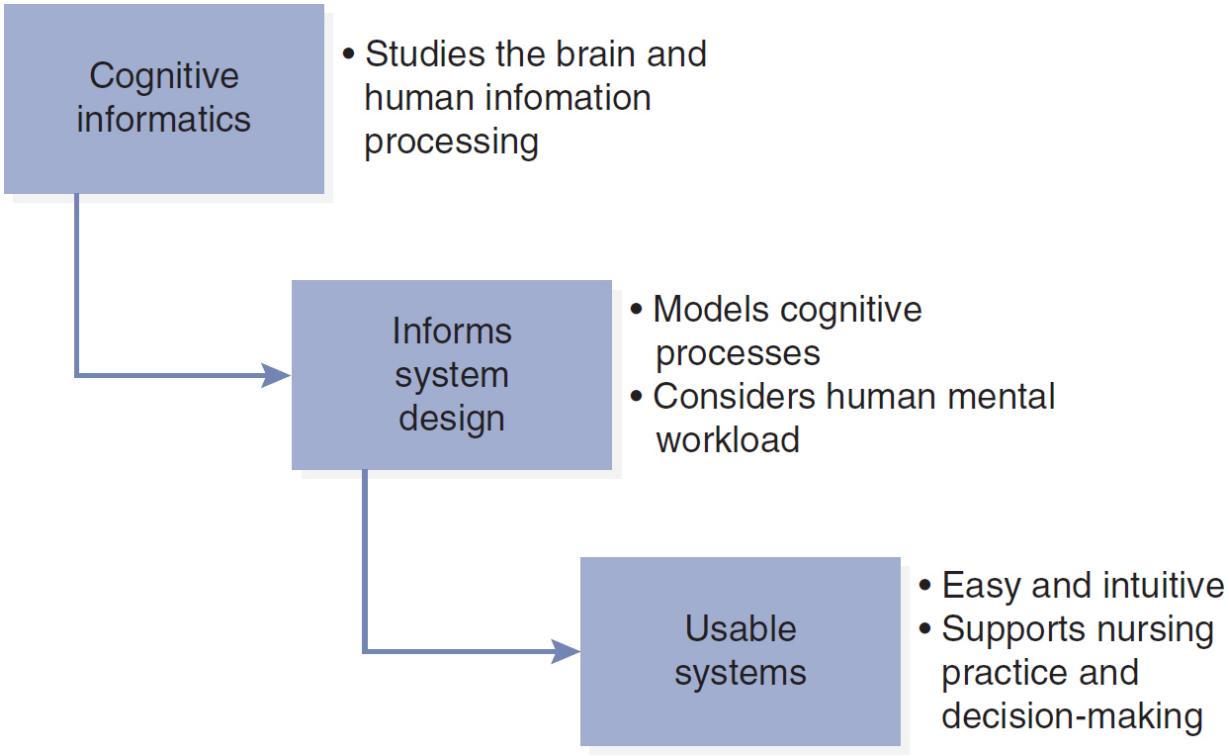


Figure 4-3 Cognitive Informatics Leads to Usable Systems

Description

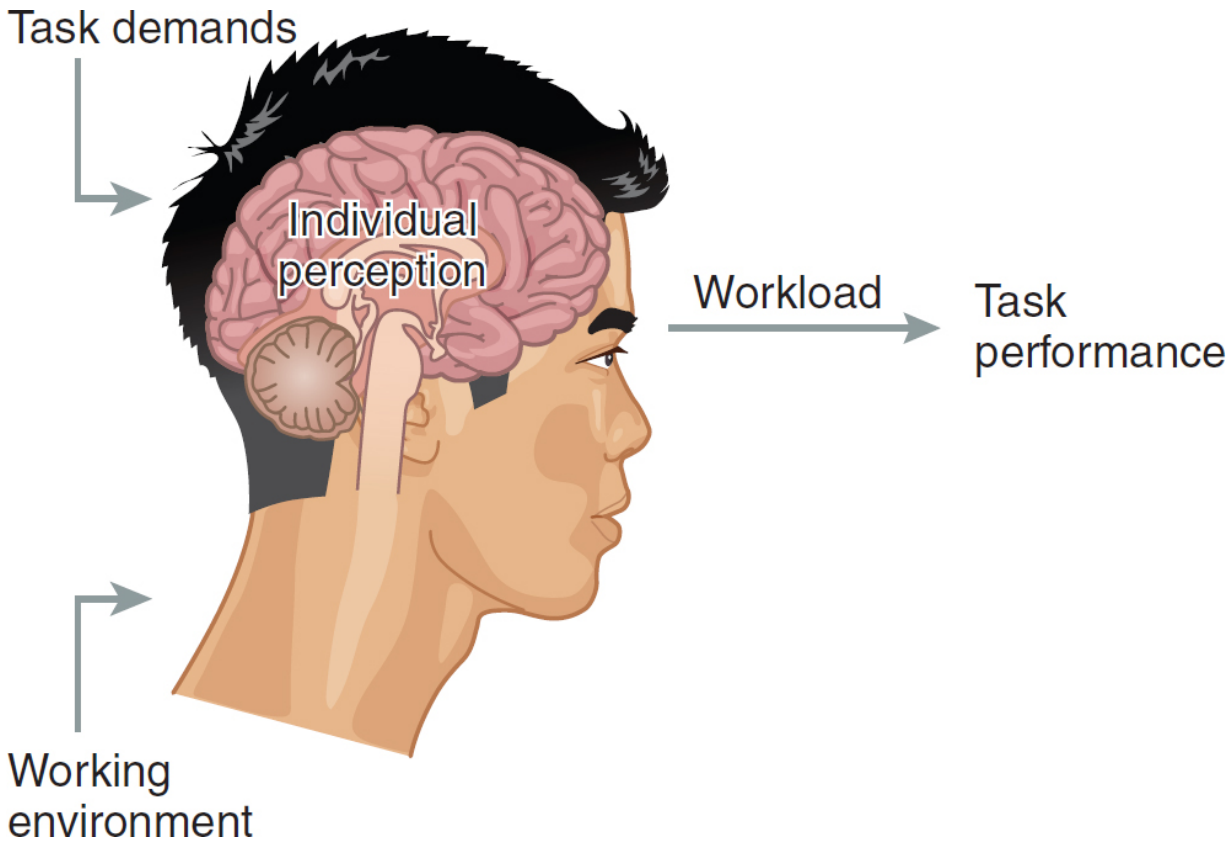


Figure 4-4 Human Mental Workload

At a low level of MWL, people may often experience annoyance and frustration when processing information. On the other hand, a high level can also be both problematic and even dangerous, as it leads to confusion, decreases performance in information processing and increases the chances of errors and mistakes. (p. 758)

Cognitive Informatics and Nursing Practice

According to Mastrian (2008), the recognition of the potential application of principles of cognitive science to NI is relatively new. The traditional and widely accepted definition of NI advanced by Graves and Corcoran (1989) is that NI is a combination of nursing science, computer science, and information science used to describe the processes nurses employ to manage data, information, and knowledge in nursing practice. Turley (1996) proposed the addition of cognitive science to this mix because nurse scientists are seen to strive to capture and explain the influence of the human brain on data, information, and knowledge processing and to elucidate how these factors in turn affect nursing decision-making. The need to include cognitive sciences is imperative as researchers attempt to model and support nursing decision-making in complex computer programs.

In 2003, Wang proposed the term *cognitive informatics* to signify the branch of information and computer sciences that investigates and explains information processing in the human brain. The science of CI grew out of interest in AI, based on computer scientists developing computer programs that mimic the information processing and knowledge generation functions of the human brain. CI bridges the gap between artificial and natural intelligence and enhances the understanding of how information is acquired, processed, stored, and retrieved so that these functions can be modeled in computer software.

What does CI have to do with nursing? At its very core, nursing practice requires problem-solving and decision-making. Nurses help people manage their responses to illnesses and identify ways that patients can maintain or restore their health. During the nursing process, nurses must first recognize that there is a problem to be solved and then they must identify the nature of the problem, pull information from knowledge stores that is relevant to the problem, decide on a plan of action, implement the plan, and evaluate the

effectiveness of the interventions. When nurses have practiced the science of nursing for some time, they tend to do these processes automatically; they instinctively know what needs to be done to intervene in the problem. What happens, however, if nurses face a situation or problem for which they have no experience on which to draw? The ever-increasing acuity and complexity of patient situations, coupled with the explosion of information in health care, has fueled the development of decision support software embedded in the electronic health record. This software models the human and natural decision-making processes of professionals in an artificial program. Such systems can help decision-makers to consider the consequences of different courses of action before implementing one of them. They also provide stores of information that users may not be aware of that they can use to choose the best course of action and ultimately make a better decision in unfamiliar circumstances.

Decision support programs continue to evolve as research in the fields of cognitive science, AI, and CI is continuously generated and then applied to the development of these systems. Nurses must embrace—not resist—these advances as support and enhancement of the practice of nursing science. Patel and Kannampallil (2015) pointed out the following:

> *CI plays a key role—both in terms of understanding, describing and predicting the nature of clinical work activities of its participants (e.g., clinicians, patients, and lay public) and in terms of developing engineering and computing solutions that can improve clinical practice (e.g., a new decision-support system), patient engagement (e.g., a tool to remind patients of their medication schedule), and public health interventions (e.g., a mobile application to track the spread of an epidemic).* (p. 4)

What Is AI?

The field of AI deals with the conception, development, and implementation of informatics tools based on intelligent technologies. This field attempts to mimic the complex processes of human thought and intelligence, using machines.

The challenge of AI use in healthcare rests in capturing, mimicking, and creating the complex processes of the mind in informatics tools, including software, hardware, and other machine technologies, with the goal that the tool be able to initiate and generate its own mechanical thought processing. The brain's processing is highly intricate and complicated. AI uses cognitive science and computer science to replicate and generate human intelligence. A self-driving car is an example of an AI system that collects, processes, and uses data to make decisions. In health care, AI systems gather and process data and make predictions of health risk and suggestions for care based on the available evidence. Examples of AI use in health care include diagnostic technologies and clinical decision support. As Luber (2011) explained, AI tools cannot be preprogramed to anticipate and respond to specific situations because of the variability and complexity of situations. "Instead, an intelligent agent must be equipped with the ability to make decisions based on the information it has, and re-evaluate its past solutions to improve future decisions" (p. 3). This field has evolved and has produced artificially intelligent tools to enhance nurses' personal and professional lives. According to Columbia University (n.d.), "[N]ow more than ever, there is unparalleled promise for what AI in health care can achieve in saving and improving lives" (para. 1). However, AI is not likely to completely replace the human functions in health care because of the complexities associated with and the emotional aspects of health care. The American Medical Association has suggested the use of the term **augmented intelligence** to emphasize the assistive role of AI

in enhancing human intelligence (www.ama-assn.org/amaone/augmented-intelligence-ai).

Those involved in developing AI do not fully understand what needs to be solved, and facets get overlooked. The complexity of healthcare challenges results in AI agents that do not perform well in the healthcare arena. The **natural language processing (NLP)** systems are still not where they need to be, especially at the provider–patient point of care, requiring the need for translators and multilingual nurses and doctors so that miscommunication or lack of communication does not disrupt care, especially in forming the patient–nurse and patient–doctor relationship, diagnosing, treating, and educating the patient (Columbia University, n.d.). It has been suggested that doctors, nurses, and other healthcare workers will not be replaced due to the need for touching patients while integrating the best technologies to improve patient outcomes (Baxter, 2019). **Machine learning (ML)** is becoming an important part of AI usage in health care. ML is a subset of AI in that machines mine vast amounts of data from various sources to identify patterns and make predictions about the data or decisions without human intervention. The data analysis outputs of ML are predictive, proactive, and preventive; they can augment and evolve the work of nurses and doctors but not replace them. Some people thought that radiologists would be replaced by AI. Instead, healthcare professionals are able to make intelligent and informed decisions through algorithmic support that meticulously and precisely processes massive amounts of data efficiently at an incredible speed and identifies patterns that were previously undetected (Columbia University, n.d.; Oracle, n.d.). The healthcare team can receive updates and analytics that are synthesized into reports, which not only decreases their workloads but also allows them to proactively care for their patients. For example, the reports can highlight primary levels of prevention issues they need to address with specific patients under their care. This is a good illustration of augmented intelligence.

AI in the Future

As electronic health records become more ubiquitous and we have access to physiological data streamed in real time, we will have the potential to process vast amounts of data using AI tools, and we will begin to see data analytics that will enable machine processing that far exceeds the capabilities of the human mind. AI is already transforming how healthcare professionals practice and the patient experience. Deloitte (n.d.) stated that "[w]hile each AI technology can contribute significant value alone, the larger potential lies in the synergies generated by using them together across the entire patient journey, from diagnoses, to treatment, to ongoing health maintenance" (para. 8). As AI continues to evolve, we will realize greater patient engagement, improved patient outcomes and quality of care, and the personalization of the levels of prevention.

Summary

Cognitive science is the interdisciplinary field that studies the mind, intelligence, and behavior from an information-processing perspective. CI is a field of study that bridges the gap in understanding regarding how information is processed in the mind and in the computer. Computing and informatics theories can be applied to help elucidate the information processing of the brain, and cognitive and neurological sciences can likewise be applied to build better and more efficient computer-processing systems.

AI is the field that deals with the conception, development, and implementation of informatics tools based on intelligent technologies. This field captures the complex processes of human thought and intelligence. AI uses cognitive science and computer science to replicate and generate human intelligence. More robust AI systems leveraging ML and deep learning techniques are likely to have a tremendous effect on health care in the future.

Clinicians must harness the sources of knowledge, the nature of knowledge, and the rapidly changing technologies to enhance their bedside care. Therefore, we must understand the nature of knowledge and knowledge processing, the information and knowledge needed, and the means by which nurses and machines process this information and knowledge in their own situational context. The reason for collecting and building data, information, and knowledge is to be able to build wisdom—that is, the ability to apply valuable and viable knowledge, experience, understanding, and insight while being prudent and sensible. Wisdom is focused on our own minds, the synthesis of our experience, insight, understanding, and knowledge. Nurses must use their wisdom and make informed, judicious, prudent, and intelligent decisions while providing care to patients, families, and communities. Cognitive science, CI, and AI will continue to evolve to help build knowledge and wisdom.

THOUGHT-PROVOKING QUESTIONS

1. How would you describe CI? Reflect on a plan of care that you have developed for a patient. How could CI be used to create tools to help with or support this important work?
2. Think of a clinical setting with which you are familiar and envision how AI tools might be applied in this setting. Are there any current tools in use? Which current or emerging tools would enhance practice in this setting and why?
3. Use your creative mind to think of a tool of the future based on CI that would support your practice.

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CHAPTER 5

Ethical Applications of Informatics

OBJECTIVES

1. Recognize ethical dilemmas in nursing informatics.
2. Examine ethical implications of nursing informatics.
3. Evaluate professional responsibilities for the ethical use of healthcare informatics technology.
4. Explore the ethical model for ethical decision-making.
5. Analyze practical ways of applying the ethical model for ethical decision-making to manage ethical dilemmas in nursing informatics.

KEY TERMS

- alternative
- antiprinciplism
- application (app)
- augmented reality (AR)
- autonomy
- beneficence
- bioethics
- bioinformatics
- care ethics
- casuist approach
- confidentiality
- consequence

- courage
- decision-making
- decision support
- duty
- ethical decision-making
- ethical dilemma
- ethical, social, and legal implications
- ethicist
- ethics
- eudaemonistic
- fidelity
- Glass
- good
- harm
- human enhancement technology (HET)
- justice
- liberty
- microblog
- microblogging
- micropost
- moral
- moral dilemma
- moral right
- negligence
- Nicomachean ethics
- nonmaleficence
- principlism
- privacy
- pseudo AI
- radio-frequency identification (RFID)
- rights
- security
- self-control
- smartphone
- social media

- standard
- truth
- über-connected world
- uncertainty
- values
- veracity
- virtue
- virtue ethics
- wisdom

Introduction

Those who followed or researched the actual events of *Apollo 13* or were entertained by the movie (Howard, 1995) watched the astronauts strive against all odds to bring their crippled spaceship back to Earth. The speed of their travel was incomprehensible to most viewers, and the task of bringing the spaceship back to Earth seemed nearly impossible. They were experiencing a crisis never imagined by the experts at NASA, and they made up their survival plan moment by moment. What brought them back to Earth safely? Surely, credit must be given to the technology and the spaceship's ability to withstand the trauma it experienced. Most amazing, however, were the traditional nontechnological tools, skills, and supplies that were used in new and different ways to stabilize the spacecraft's environment and keep the astronauts safe while traveling toward their uncertain future.

This sense of constancy in the midst of change serves to stabilize experience in many life events and contributes to the survival of crisis and change. This rhythmic process is also vital to the healthcare system's stability and survival in the presence of the rapidly changing events of the Knowledge Age. No one can dispute the fact that the Knowledge Age is changing health care in ways that will not be fully recognized and understood for years. The change is paradigmatic, and every expert who addresses this change reminds healthcare professionals of the need to go with the flow of rapid change or be left behind.

As with any paradigm shift, a new way of viewing the world brings with it some of the enduring **values** of the previous worldview. As health care continues its journey into digital communications, telehealth, and wearable technologies, it brings some familiar tools and skills recognized in the form of values, such as **privacy**, **confidentiality**, autonomy, and nonmaleficence. Although these basic values remain unchanged, the **standards** for living out these values will take on new meaning as health professionals confront

new and different moral dilemmas brought on by the adoption of technological tools for information management, knowledge development, and evidence-based changes in patient care. **Ethical decision-making** frameworks will remain constant, but the context for examining these moral issues, or **ethical dilemmas**, will become increasingly complex.

This chapter highlights some familiar ethical concepts to consider on the challenging journey into the increasingly complex future of healthcare informatics. Ethics and bioethics are briefly defined, and the evolution of ethical approaches from the Hippocratic ethic era, to **principlism**, to the current **antiprinciplism** movement of ethical decision-making is examined. New and challenging ethical dilemmas are surfacing in the venture into the unfolding era of healthcare informatics (**Figure 5-1**). Also presented in this chapter are findings from some of the more recent literature related to these issues. Readers are challenged to think constantly and carefully about ethics as they become involved in healthcare informatics and to stay abreast of new developments in ethical approaches.



Figure 5-1 Ethics in Health Care

Ethics

Ethics is a process of systematically examining varying viewpoints related to moral questions of right and wrong. **Ethicists** have defined the term in a variety of ways, with each definition reflecting a basic theoretical philosophic perspective.

Beauchamp and Childress (1994) referred to ethics as a generic term for various ways of understanding and examining the moral life. Ethical approaches to this examination may be normative, presenting standards of right, or **good** action; descriptive, reporting what people believe and how they act; or explorative, analyzing the concepts and methods of ethics.

Husted and Husted (1995) emphasized a practice-based ethics, stating that "ethics examines the ways men and women can exercise their power in order to bring about human benefit—the ways in which one can act in order to bring about the conditions of happiness" (p. 3).

Velasquez et al. (2010) posed the question, "What is ethics?" They answered it with the following two-part response: "First, ethics refers to well-based standards of right and wrong that prescribe what humans ought to do, usually in terms of rights, obligations, benefits to society, fairness, or specific virtues" (para. 10). "Secondly, ethics refers to the study and development of one's ethical standards" (para. 11).

Regardless of the theoretical definition, a common characteristic regarding ethics is its dialectical, goal-oriented approach to answering questions, which allows for the potential for multiple acceptable answers.

Bioethics

Bioethics is defined as the study and formulation of healthcare ethics. Bioethics takes on relevant ethical problems experienced by healthcare providers in the provision of care to individuals and groups. Husted and Husted (1995) stated that the fundamental background of bioethics that forms its essential nature is as follows:

1. The nature and needs of humans as living, thinking beings
2. The purpose and function of the healthcare system in a human society
3. An increased cultural awareness of human beings' essential moral status (p. 7)

Bioethics emerged in the 1970s as health care began to change its focus from a mechanistic approach of treating disease to a more holistic approach of treating people with illnesses. As technology advanced, recognition and acknowledgment of the **rights** and the needs of individuals and groups receiving this high-tech care also increased.

In today's technologically savvy healthcare environment, in some clinical practices, patients are being prescribed **applications (apps)** for their **smartphones** instead of medications. Patients' smartphones are being used to interact with them in new ways and to monitor and assess their health in some cases. With apps and add-ons, for example, a provider can see the patient's ECG immediately, or the patient can monitor their ECG and send it to the provider as necessary. Another example would be a sensor attached to the patient's mobile device that could monitor blood glucose levels. We are just beginning to realize the vast potential of these mobile devices—and the threats they can pose. For example, Google's **Glass**, which is an **augmented reality (AR)** headset that provides an interactive experience within a real-world environment, has been updated for the workplace (Brown, 2019). On the one

hand, this wearable device can take photos and videos without anyone knowing that this is occurring; in the healthcare environment, such a technological advancement can violate patients' privacy and confidentiality. On the other hand, wearable technologies provide a data-rich environment for diagnosing, addressing, and monitoring health issues. As we analyze huge patient datasets, concerns arise about privacy, confidentiality, and data sharing.

The use of robotics in healthcare is causing disruption. Segers (2022) felt the predominant concern was that the "implementation of care robots will turn deception into a routine component of elderly care, at least to the extent that these robots will function as simulacra for something that they are not (i.e. human caregivers)" (para. 1). Even though they might create a paradigm shift in the current healthcare system and provider–patient relationships, there could be a reawakening, reexamination, and reassessment of **veracity** (Segers, 2022). The **virtue** of veracity is one of the values that is employed to lobby against a "substitution of human caregivers (while a combination of care robots and human caregivers is much more accepted)" (Segers, 2022, para. 1). Add these evolving developments to healthcare providers' engagement in social media use with their patients, and it becomes clear that personal and ethical dilemmas abound for nurses in the new **über-connected world** through social media tools, such as wikis, blogs, and other social networks, which are connecting employees, patients, healthcare providers, and other people globally.

Ethical Issues and Social Media

As connectivity has improved, owing to emerging technologies, a rapid explosion in the phenomenon known as social media has occurred. **Social media** is defined as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0 and that allow the creation and exchange of user-generated content" (Spector & Kappel, 2012). Just as the electronic health record serves as a real-time event in recording patient–provider contact, so too does the use of social media represent an instantaneous form of communication. Healthcare providers—particularly nurses—can enhance the patient care delivery system, promote professional collegiality, and provide timely communication and education regarding health-related matters by using this forum (National Council of State Boards of Nursing, 2011; National Student Nurses' Association, n.d., p. 4). In all cases, however, nurses must exercise judicious use of social media to protect patients' rights. Nurses must understand their obligation to their chosen profession, particularly as it relates to personal behavior and the perceptions of their image as portrayed through social media. Above all, nurses must be mindful that once communication is written and posted on the internet, there is no way to retract what was written; it is a permanent record that can be tracked, even if the post is deleted (Englund et al., 2012, p. 242). In recent years, more patients are using social media to discuss not only their stories but also their healthcare providers and healthcare settings. Foot et al. (2021) felt that people were inclined to trust those who posted comparable experiences and points of view like their own. One parent felt that her "large social media following influenced her daughter's doctor's willingness to try interventions identified through social media" (Foot et al., 2021, p. 9). Zakkar et al. (2022) researched the issue from the perspectives of healthcare providers and administrators to investigate if they could use the stories to assess healthcare experiences. Their study found that the healthcare

system's culture might need to change to foster the use of social media to improve the quality of healthcare. In addition, the changes might be required to "enable the development of a safe patient-provider communication environment that facilitates the exchange of constructive feedback between the two parties without the fear of legal consequences, breaches of patient privacy, or violation of professional codes of conduct" (Zakkar et al., 2022, para. 1). The healthcare providers and administrators must formulate a plan on how they will continue to acknowledge, access, evaluate, and act on the social media posts of their consumers—their patients.

Social media platforms include such electronic communication outlets as Facebook, WhatsApp, X (formerly Twitter; **microblogging** site), TikTok, LinkedIn, Instagram, Snapchat, WeChat, Douyin, and YouTube. Other widely used means of instantaneous communications include wikis, blogs, tweeting, Skype, Instagram, and the "hangout" feature on Google+. Use of social networking has increased dramatically among all age groups. There are 4.61 billion social media users out of a global population of 7.91 billion (Kemp, 2022). Chaffey (2023) reported that "59% of the world's population uses social media. The average daily usage is 2 hours and 29 minutes" (para. 4.). Kemp listed the favorite social media platforms for people aged 16 to 64 in the following order with the percentage of users choosing their favorite top seven social media in parentheses: WhatsApp (15.7%); Instagram (14.8%); Facebook (14.5%); WeChat (11.4%); Douyin (5.1%); TikTok (4.3%); and X (Twitter) (3.3%). WhatsApp has over 100 billion messages shared every day (Dean, 2023c). Instagram has over 500 million daily active users worldwide (Dean, 2023b). Facebook has 1.9 billion daily users who access its platform (Dean, 2023a).

X (Twitter) is a social media **microblog** platform that allows users to microblog **microposts**, or frequent, short posts. X's (Twitter's) influence on health care continues to grow, according to Pershad et al. (2018). Symplur (n.d.) reported 2,000,000,000+ tweets related to health care, covering 17,265 topics. X (Twitter, n.d.) is driving the consumer and provider connection in health care. In addition, healthcare consumers can connect to share their treatment

experiences. Healthcare providers were typically connected to information as well as other members of their discipline or other members of the healthcare team through their attendance at conferences (Twitter, n.d.). The COVID-19 pandemic changed that since conferences moved from face-to-face to virtual venues with "an evergreen conversation, where more than 60 percent of the conference dialogue was happening outside conference windows with hashtags like #ASCO22 and #ANA22. HCPs [healthcare practitioners] used the conference hashtag to connect with their peers and share information" (Twitter, n.d., para. 5). This change in connection among professionals opened the door for conference exhibitors to develop digital targeted marketing efforts for year-round strategies instead of only materials for face-to-face encounters typically used for conferences (Twitter, n.d.).

Given the magnitude of people using social media, it is almost a given that our patients are using one or more of the social media platforms. Therefore, we must capitalize on its use and leverage the opportunities that exist within these forums. The need to maintain confidentiality presents a major obstacle to the healthcare industry's widespread adoption of such technology as well as the ethical implications when using social networking venues. Healthcare professionals as well as patients must consider how social media affects the delivery and support of healthcare. We must comprehend how engaging in these social media platforms affects patient outcomes in relation to attitudes, behavior, and information needs for the patient; their significant others; caregivers; and healthcare providers. There is a need for correlational research that explores these factors as well as others over an extended period of time to inform us about the consequence of engaging in or limiting the use of these platforms throughout our healthcare connections.

The prevalent use of smartphones by providers and patients is another perplexing facet because smartphones have the capability to take still pictures as well as live recordings with or without audio and they come with the patients and providers into healthcare settings, including treatment rooms, patient rooms, and other provider–patient relationship areas.

As a consequence of more stringent confidentiality laws and widespread availability and use of social and mobile media, numerous ethical and legal dilemmas have been posed to nurses. What still are not well defined are the expectations of healthcare providers regarding this technology. In some cases, nurses employed in the emergency department setting have been subjected to video and audio recordings by patients and families when they perform procedures and provide care during such visits. Nurses would be wise to inquire—before an incident occurs—about the hospital policy regarding audio/video recording by patients and families as well as the state laws governing two-party consent. Sigman (2019) reminded us that the federal wiretapping law (18 U.S. Code § 2511) "requires that only one party consent to recording a conversation. States also have laws governing recording. In most cases, state laws that are more restrictive than federal law would supersede the federal statute" (para. 4).

Sometimes the enthusiasm for patient care and learning can lead to ethics violations. Over the years many violations have been cited. In one case, an inadvertent violation of privacy laws occurred when a nurse in a small town blogged about a child in her care whom she referred to as her "little handicapper." The post also noted the child's age and the fact that the child used a wheelchair. A complaint about this breach of confidentiality was reported to the Board of Nursing. A warning was issued to the nurse blogging this information, although a more stringent disciplinary action could have been taken (Spector & Kappel, 2012, p. 2). In another case cited by Spector and Kappel, a student nurse cared for a 3-year-old leukemia patient whom she wanted to remember after finishing her pediatric clinical experience. She took the child's picture, and in the background of the photo, the patient's room number was clearly displayed. The child's picture was posted on the student nurse's Facebook page along with her statement of how much she cared about this child and how proud she was to be a student nurse. Someone forwarded the picture to the nurse supervisor of the children's hospital. Not only was the student expelled from the program but also the clinical site offer made by the children's hospital to the nursing school was rescinded.

In addition, the hospital faced citations for violations of the Health Insurance Portability and Accountability Act (HIPAA), owing to the student nurse's transgression (p. 3). Sometimes nurses use social network sites, blogs, and microblogs about the patients they care for believing that if they omit the patient's name, they are not violating the patient's privacy and confidentiality. "A nurse who posts about caring for an 85-year-old female in her city could cause the patient to be identified by content in the post. This action does not protect the patient" (Henderson & Dahnke, 2015, p. 63).

Adler (2023) summarized recent incidents involving nurses where they took "photographs and videos of patients in compromising positions, recording abuse of patients in nursing homes, and taking embarrassing or degrading photographs and sharing them with friends via social media networks" (para. 12). As reflected in these violations, nurses must always think and think again before posting. It is important to review the do's and don'ts such as those of Brown (2022), who provided guidelines for nurses using social media for nurse.org.

Ethical Dilemmas and Morals

An ethical dilemma arises when moral issues raise questions that cannot be answered with a simple, clearly defined rule, fact, or authoritative view. **Morals** refer to social conventions about right and wrong human conduct that are so widely shared that they form a stable (although usually incomplete) communal consensus (Beauchamp & Childress, 1994). **Moral dilemmas** arise with **uncertainty**, as is the case when a person is confronted with evidence that indicates an action is morally right and other evidence that indicates the same action is morally wrong. Uncertainty is stressful and, in the face of inconclusive evidence on both sides of the dilemma, causes the person to question what they should do. Sometimes the individual concludes that based on their moral beliefs, they cannot act. Uncertainty also arises from unanticipated effects or unforeseeable behavioral responses to actions or the lack of action. Adding uncertainty to the situational factors and personal beliefs that must be considered creates a need for an ethical decision-making model to help one choose the best action.

Ethical Decision-Making

Ethical decision-making refers to the process of making informed choices about ethical dilemmas based on a set of standards differentiating right from wrong. This type of **decision-making** reflects an understanding of the principles and standards of ethical decision-making, as well as the philosophic approaches to ethical decision-making, and it requires a systematic framework for addressing the complex and often controversial moral questions.

In this high-speed era of digital communication, the rights and needs of individuals and groups is of the utmost concern to all healthcare professionals. The changing meaning of communication, for example, will bring with it new concerns among healthcare professionals about protecting patients' rights of confidentiality, privacy, and autonomy. Systematic and flexible ethical decision-making abilities are essential for all healthcare professionals.

Notably, the concept of nonmaleficence ("do no harm") will be broadened to include those individuals and groups that one may never see in person but with whom one will enter into a professional relationship of trust and care. As early as 2000, Mack discussed the popularity of individuals seeking information online, instead of directly from their healthcare providers, and the effects this behavior has on patient–provider relationships. This has increased over the years, and currently many people look to the internet first before seeking information and care from healthcare professionals. Mack is emphatic in his reminder that "organizations and individuals that provide health information on the Internet have obligations to be trustworthy, provide high-quality content, protect users' privacy, and adhere to standards of best practices for online commerce and online professional services in healthcare" (p. 41).

Makus (2001) suggested that both autonomy and justice are enhanced with universal access to information but that tensions may be created in patient–provider relationships as a result of this access to outside information. This has only increased, and currently

healthcare workers realize that they are not the sole providers and gatekeepers of health-related information. As patients share and seek healthcare information on social media and from other online websites, it is the responsibility of healthcare providers to embrace information empowerment, discuss what their patients share from social media, and suggest websites and apps to patients that contain reliable, accurate, timely, and relevant information.

It is clear that patients' increasing use of the internet for healthcare information may prompt entirely new types of ethical issues, such as who is responsible if a patient is harmed as a result of following online health advice. Derse and Miller (2008) discussed this issue extensively and concluded that a clear line separates information and practice. Practice occurs when there is direct or personal communication between the provider and the patient, the advice is tailored to the patient's specific health issue, and there is a reasonable expectation that the patient will act in reliance on the information.

A summit sponsored by the Internet Healthcare Coalition in 2000 developed the eHealth Code of Ethics (eHealth Ethics Initiative, 2000), which includes eight standards for the ethical development of health-related internet sites: (1) candor, (2) honesty, (3) quality, (4) informed consent, (5) privacy, (6) professionalism, (7) responsible partnering, and (8) accountability. For more information about each of these standards, access the full discussion of the eHealth Code of Ethics (www.ihealthcoalition.org/wp-content/themes/IHC-theme/code0524.pdf).

It is important to realize that the standards for ethical development of health-related internet sites are voluntary; there is no overseer perusing these sites and issuing safety alerts for users. Although some sites carry a specific symbol indicating that they have been reviewed and are trustworthy (e.g., HONcode and TRUSTe), the healthcare provider cannot control the amount of patient engagement, which information patients access, or how they perceive and act related to the health information they find online. The research briefs previously presented described one study of consumer perceptions of health information on the web, another

study that explored ethics and consumer engagement in nursing, and a study profiling cancer patients based on their motives for seeking informational and emotional support online.

Theoretical Approaches to Healthcare Ethics

Theoretical approaches to healthcare ethics have evolved in response to societal changes. In a 30-year retrospective article for the *Journal of the American Medical Association*, Pellegrino (1993) traced the evolution of healthcare ethics from the Hippocratic ethic, to principlism, to the current antiprinciplism movement.

The Hippocratic tradition emerged from relatively homogeneous societies in which beliefs were similar and most societal members shared common values. The emphasis was on **duty**, virtue, and gentlemanly conduct.

Principlism arose as societies became more heterogeneous and members began experiencing a diversity of incompatible beliefs and values; it emerged as a foundation for ethical decision-making. Principles were expansive enough to be shared by all rational individuals, regardless of their backgrounds and individual beliefs. This approach continued into the 1900s and was popularized by two bioethicists, Beauchamp and Childress (1977; 1994), in the last quarter of the 20th century. Principles are considered broad guidelines that provide guidance or direction but that leave substantial room for case-specific judgment. From principles, one can develop more detailed rules and policies.

RESEARCH BRIEFS

CONSUMER PERCEPTIONS OF HEALTH INFORMATION ON THE WEB

Using an online survey of 1,227 randomly selected respondents, Bodkin and Miaoulis (2007) sought to describe the characteristics of information seekers on eHealth websites, the types of information they seek, and their perceptions of the quality and ethics of the websites. Of the respondents, 74% had sought health information on the web, with women accounting for 55.8% of the health information seekers. A total of 50% of the seekers were between 35

and 54 years of age. Nearly two thirds of the users began their searches using a general search engine rather than a health-specific site, unless they were seeking information related to symptoms or diseases. The top reasons for seeking information were related to diseases or symptoms of medical conditions, medication information, health news, health insurance, locating a doctor, and Medicare or Medicaid information. The level of education of information seekers was related to the ratings of website quality in that more educated seekers found health information websites more understandable but were more likely to perceive bias in the website information. The researchers also found that the ethical codes for eHealth websites seem to be increasing consumers' trust in the safety and quality of information found on the web but that most consumers are not comfortable purchasing health products or services online.

ETHICS AND CONSUMER ENGAGEMENT IN NURSING

Hassmiller and Bilazarian (2018) explored consumer engagement and its relationship to safety, quality, and ethics to identify promising practices and leadership strategies. The literature review was supplemented with interviews from 25 key nursing informants. They described examples illustrating business, ethical, and quality cases and noted that we must pay attention to all three types of cases for the synergy needed for optimal clinical effectiveness and consumer engagement. Interviewees highlighted the ethics cases and the idea that nurse leaders have an ethical responsibility to lead in the area of consumer engagement by committing to the values of compassion, patient advocacy, and consumer engagement and translating those values to the patient. It was important to note that technology can add to or detract from opportunities for engagement with consumers based on the use of the tools and the amount of disruption. This study identified strategies and organizational changes necessary to enhance partnering with healthcare consumers while supporting the quality and safety, business, and ethics cases needed for consumer engagement.

MOTIVES FOR SEEKING INFORMATIONAL AND EMOTIONAL SUPPORT ONLINE

Duimel et al. (2022) sought to identify theoretically founded profiles of cancer patients varying in their motives for seeking informational and/or emotional support online based on the stress and coping theory and the uses and gratifications theory. The researchers also wanted to compare the profiles in terms of these patients' psychological and background attributes and their perception of healthcare services. Duimel et al. conducted a hierarchical cluster analysis using questionnaire data from patients who visited a large

Dutch health website (N = 181). This uncovered three unique profiles: (1) overall seekers (*n* = 83, 46.0%); (2) occasional information seekers (*n* = 83, 46.0%); and (3) contact exchangers (*n* = 15, 8.0%). Patients across these profiles varied in their eHealth literacy, with the contact exchangers being more eHealth literate than the overall seekers and occasional information seekers. It is important to comprehend why patients seek informational and/or emotional support online to provide them with accurate and reliable support that addresses their needs, preferences, and personal situational context. The results can be used to create awareness among healthcare providers to help them tailor recommendations for and development of online resources that fit the patients' needs. This study was the first to explore individual variations across groups of cancer patients that seek support online.

Beauchamp and Childress (1994) proposed four guiding principles: (1) respect for autonomy, (2) nonmaleficence, (3) beneficence, and (4) justice.

- **Autonomy** refers to an individual's freedom from controlling interferences by others and from personal limitations that prevent meaningful choices, such as inadequate understanding. Two conditions are essential for autonomy: **liberty**, meaning independence from controlling influences, and an individual's capacity for intentional action.
- **Nonmaleficence** asserts an obligation not to inflict **harm** intentionally and forms the framework for the standard of due care to be met by any professional. Obligations of nonmaleficence are those of not inflicting harm and not imposing risks of harm.
- **Negligence**, which is a departure from the standard of due care toward others, includes intentionally imposing risks that are unreasonable and unintentionally but carelessly imposing risks.
- **Beneficence** refers to actions performed that contribute to the welfare of others. Two principles underlie beneficence: positive beneficence requires the provision of benefits, and utility requires that benefits and drawbacks be balanced. One must avoid negative beneficence, which occurs when constraints are

placed on activities that, even though they might not be unjust, could in some situations cause detriment or harm to others.

- **Justice** refers to fair, equitable, and appropriate treatment in light of what is due or owed to a person. Distributive justice refers to fair, equitable, and appropriate distribution in society as determined by justified norms that structure the terms of social cooperation.

Beauchamp and Childress (1994) also suggested three types of rules for guiding actions: substantive, authority, and procedural. (Rules are more restrictive in scope than principles and more specific in content.) Substantive rules are rules of truth telling, confidentiality, privacy, and **fidelity** and those pertaining to the allocation and rationing of health care, omitting treatment, physician-assisted suicide, and informed consent. Authority rules indicate who may and should perform actions. Procedural rules establish the procedures to be followed.

The principlism advocated by Beauchamp and Childress has since given way to the antiprinciplism movement, which emerged in the 21st century with the expansive technological changes and tremendous rise in ethical dilemmas accompanying these changes. Opponents of principlism include those who claim that its principles do not represent a theoretical approach and those who claim that its principles are too far removed from the concrete particularities of everyday human existence because they are too conceptual, intangible, or abstract or they disregard a person's psychological factors; personality; life history; sexual orientation; or religious, ethnic, and cultural background. Next, different approaches to making ethical decisions are briefly explored to provide the reader with an understanding of the varied methods professionals may use to arrive at an ethical decision.

The **casuist approach** to ethical decision-making grew out of the call for more concrete methods of examining ethical dilemmas. Casuistry is a case-based ethical reasoning method that analyzes the facts of a case in a sound, logical, ordered, and structured manner.

The facts are compared to decisions arising out of consensus in previous paradigmatic, or model, cases. One casuist proponent, Jonsen (1991), preferred particular and concrete paradigms and analogies over the universal and abstract theories of principlism.

The Husted bioethical decision-making model centers on the healthcare professional's implicit agreement with the patient or client (Husted & Husted, 1995). It is based on six contemporary bioethical standards: (1) autonomy, (2) freedom, (3) veracity, (4) privacy, (5) beneficence, and (6) fidelity.

The **virtue ethics** approach emphasizes the virtuous character of individuals who make the choices. A virtue is any characteristic or disposition desired in others or oneself. It is derived from the Greek word *aretai*, meaning "excellence," and refers to what one expects of oneself and others. Virtue ethicists emphasize the ideal situation and attempt to identify and define ideals. Virtue ethics dates back to Plato and Socrates. When asked "whether virtue can be taught or whether virtue can be acquired in some other way, Socrates answers that if virtue is knowledge, then it can be taught. Thus, Socrates assumes that whatever can be known can be taught" (Scott, 2002, para. 9). According to this view, the cause of any moral weakness is not a matter of character flaws but rather a matter of ignorance. In other words, a person acts immorally because the individual does not know what is really good for themselves. A person can, for example, be overpowered by immediate pleasures and forget to consider the long-term consequences. Plato emphasized that to lead a moral life and not succumb to immediate pleasures and gratification, one must have a moral vision. He identified four cardinal virtues: (1) **wisdom**, (2) **courage**, (3) **self-control**, and (4) justice.

Aristotle's (2009) **Nicomachean ethics** also contribute to virtue ethics. According to Aristotle, virtues are connected to will and motive because the intention is what determines whether one is or is not acting virtuously. Ethical considerations, according to his **eudaemonistic** principles, address the question, "What is it to be an excellent person?" For Aristotle, being an excellent person

ultimately means acting in a temperate manner according to a rational mean between extreme possibilities.

Virtue ethics has experienced a recent resurgence in popularity (Energetic Synthesis, 2016). Two of the most influential moral and medical authors, Pellegrino and Thomasma (1993), have maintained that virtue theory should be related to other theories within a comprehensive philosophy of the health professions. They argued that moral events are composed of four elements (i.e., the agent, the act, the circumstances, and the **consequences**) and that a variety of theories must be interrelated to account for different facets of moral judgment.

Care ethics is responsiveness to the needs of others, which dictates providing care, preventing harm, and maintaining relationships. This viewpoint has been in existence for some time. Engster (2004) stated that "Carol Gilligan's *In a Different Voice* (1982) established care ethics as a major new perspective in contemporary moral and political discourse" (p. 113). The relationship between care and virtue is complex, however. Benjamin and Curtis (1992) based their framework on care ethics; they propose that "critical reflection and inquiry in ethics involves the complex interplay of a variety of human faculties, ranging from empathy and moral imagination on the one hand to analytic precision and careful reasoning on the other" (p. 12). Care ethicists are less stringently guided by rules than by a focus on the needs of others and the individual's responsibility to meet those needs. As opposed to the aforementioned theories that are centered on the individual's rights, an ethic of care emphasizes the personal part of an interdependent relationship that affects how decisions are made. In this theory, the specific situation and context in which the person is embedded become a part of the decision-making process.

The consensus-based approach to bioethics was proposed by Martin (1999), who claimed that American bioethics harbors a variety of ethical methods that emphasize different ethical factors, including principles, circumstances, character, interpersonal needs, and personal meaning. Each method reflects an important aspect of ethical experience, adds to the others, and enriches the ethical

imagination. Thus, working with these methods provides the challenge and the opportunity necessary for the perceptive and shrewd bioethicist to transform them into something new and valuable through the process of building ethical consensus. Diverse ethical insights can be integrated to support a particular bioethical decision, and that decision can be understood as a new, ethical whole.

Applying Ethics to Informatics

With the Knowledge Age has come global closeness, meaning the ability to reach around the globe instantaneously through technology. Language barriers are being broken through technologically based translators, which can enhance interaction and exchange of data and information. Informatics practitioners are bridging continents, and international panels, committees, and organizations have established standards and rules for the implementation of informatics. This international perspective must be considered when informatics dilemmas are examined from an ethical standpoint; it promises to influence the development of ethical approaches that begin to accept that healthcare practitioners are working within international networks and must recognize, respect, and regard the diverse political, social, and human factors within informatics ethics.

The various ethical approaches can be used to help healthcare professionals make ethical decisions in all areas of practice. The focus of this text is on informatics. Informatics theory and practice have continued to grow at a rapid rate and infiltrate every area of professional life. New applications and ways of performing skills are being developed daily. Therefore, education in informatics ethics is extremely important.

Typically, situations are analyzed using past experience and in collaboration with others. Each situation warrants its own deliberation and unique approach because each individual patient seeking or receiving care has their own preferences, quality of life, and healthcare needs in a situational milieu framed by financial, provider, setting, institutional, and social context issues. Clinicians must consider all these factors when making ethical decisions.

The use of expert systems, **decision support** tools, evidence-based practice, and artificial intelligence in the care of patients creates challenges in terms of who should use these tools, how they are implemented, and how they are tempered with clinical

judgment. Reflect on the ethical issues presented in the following Ethical Issues to Ponder.

All clinical situations are not the same, and even though the result of interacting with these systems and tools is enhanced information and knowledge, the clinician must weigh this information in light of each patient's unique clinical circumstances, including that individual's beliefs and wishes. Patients are demanding access to quality care and the information necessary to control their lives. Clinicians need to analyze and synthesize the parameters of each distinctive situation using a specific decision-making framework that helps them make the best decisions. Getting it right the first time has a tremendous impact on expected patient outcomes. The focus should remain on patient outcomes while the informatics tools available are ethically incorporated.

Facing ethical dilemmas on a daily basis and struggling with unique client situations may cause many clinicians to question their own actions and the actions of their colleagues and patients. One must realize that colleagues and patients may reach very different decisions, but that does not mean anyone is wrong. Instead, all parties reach their ethical decision based on their own review of the situational facts and understanding of ethics. As one deals with diversity among patients, colleagues, and administrators, one must constantly strive to use ethical imagination to reach ethically competent decisions.

Balancing the needs of society, their employer, and their patients could cause the clinician to face ethical challenges on an everyday basis. Society expects judicious use of finite healthcare resources. Employers have their own policies, standards, and practices that sometimes can inhibit the practice of the clinician. Each patient is unique and has life experiences that affect their healthcare perspective, choices, motivation, and adherence. Combine all these factors with the challenges posed by informatics, and it is clear that the evolving healthcare arena calls for an informatics-competent, politically active, consumer-oriented, business-savvy, ethical clinician to rule this ever-changing landscape known as health care.

ETHICAL ISSUES TO PONDER

FAKING ARTIFICIAL INTELLIGENCE (AI), OR PSEUDO AI?

Schmelzer (2020) discussed the technical and data-driven complexities of AI that challenge technology companies to deliver on their AI promises. Companies that cannot navigate the complexities of AI employ human impostors who fake AI by pretending to be the machines assigned to do the work of the humans. **Pseudo AI** is when humans complete the tasks assigned to AI, thus undermining the entire premise of AI. AI can realize accomplishments that only humans were thought capable of not so many years ago. AI is an evolving field, and new AI technologies are emerging daily. What are the ethical considerations for faking AI?

HUMAN ENHANCEMENT TECHNOLOGY

Human enhancement technology (HET) refers to biomedical and other technology that augments a person using human–machine integration, such as the use of artificial limbs or other prosthetics. Such technology can make a healthy person healthier or stronger or a smart person even smarter using pharmaceutical enhancements and human genetic engineering. As with all technologies, ethical questions arise. RoboticsBiz (2019) asked about the impact of HET on how we will define future human beings. It further discussed the idea of equality and whether enhancements provide advantages. Another equality issue relates to the ability of the wealthy to obtain expensive enhancements. Will we be able to distinguish between healing and enhancement? What ethical dilemmas can you foresee?

ARE WE READY TO REPLACE DOCTORS WITH MACHINES USING AI?

Kumar (2018) discussed the strides made in analytics and machine learning capabilities in health care in relation to the potential replacement of physicians. According to Kumar, there are three issues delaying such a move: obstacles, ethical issues, and limitations. The obstacles include slow adoption of technologies in health care and machine learning issues related to time series and natural language processing, which are weaknesses of machine learning algorithms.

The ethical issues surround healthcare analytics, bias, patient privacy, and assessing human feelings or pain. Kumar raised an excellent question. If AI creates a model found to contain errors, who is responsible, the physician caring for the patient or the scientists who developed the model? Limitations

center on the nonhuman factors. Robots and computers are machines and are not perceived as human. They cannot replace a human care provider's capacity to afford comfort, support, and compassion.

IMPLICATIONS OF IMPLANTED RADIO-FREQUENCY IDENTIFICATION AND NEAR FIELD COMMUNICATION

There has been an increase in the implantation of **radio-frequency identification (RFID)** and near field communication (NFC) tags. They can be located in devices such as pacemakers. According to Offenbaker (2017), "Recently, Medtronic introduced a pacemaker that can be monitored remotely through a smartphone application through iOS and/or Android smartphones" (para. 4). These tags can also be implanted within patients who have been diagnosed with Alzheimer's and who are a flight risk to track their location. Weiss (2018) stated that "Microchip implants are going from tech-geek novelty to genuine health tool—and you might be running out of good reasons to say no" (para. 1). According to Offenbaker, one of the most common reasons people do not want to accept these tags is to guard their privacy. People are also concerned that these tags will be implanted without their knowledge, and it is not reassuring to some that they would require informed consent. What are the ethical implications arising from the use of implantable tags?

The goal of any ethical system should be that a rational, justifiable decision be reached. Ethics is always there to help the practitioner decide what is right. Indeed, the measure of an adequate ethical system, theory, or approach is in part its ability to be useful in novel contexts. A comprehensive, robust theory of ethics should be up to the task of addressing a broad variety of new applications and challenges at the intersection of informatics and health care.

To be useful, the information concerning an ethical dilemma must be viewed in the context of the dilemma. **Bioinformatics** could gather, manipulate, classify, analyze, synthesize, retrieve, and maintain databases related to ethical cases; the effective reasoning applied to various ethical dilemmas; and the resulting ethical decisions. This input would certainly be potent, but the resolution of dilemmas cannot be achieved simply by examining relevant cases from a database. Instead, clinicians must assess each situational context and the patient's specific situation and needs and make their ethical decisions based on the information they have at hand.

Ethics is exciting, and competent clinicians need to know about ethical dilemmas and solutions in their professions. Ethicists have often been thought of as experts in the arbitrary, ambiguous, and ungrounded judgments of other people. They know that they make the best decisions they can based on the situation and stakeholders at hand. Just as clinicians try to make the best healthcare decisions with and for their patients, ethically driven practitioners must do the same. Each healthcare provider must critically think through the situation to arrive at the best decision.

To make ethical decisions about informatics technologies and patients' intimate healthcare data and information, the healthcare provider must be competent in informatics. To the extent that information technology is reshaping healthcare practices or promises to improve patient care, healthcare professionals must be trained and competent in the use of these tools. This competency needs to be evaluated through instruments developed by professional groups or societies; such assessment will help with consistency and quality. For the healthcare professional to be an effective patient advocate, they must understand how information technology affects the patient and the subsequent delivery of care. Information science and its effects on health care are both interesting and important. It follows that information technology and its **ethical, social, and legal implications** should be incorporated into all levels of professional education.

The need for confidentiality was perhaps first articulated by Hippocrates. Thus, if anything is different in today's environment, it is simply the ways in which confidentiality can be violated. Perhaps the use of computers for clinical decision support and data mining in research will raise new ethical issues. Ethical dilemmas associated with the integration of informatics must be examined to provide an ethical framework that considers all stakeholders. Patients' rights must be protected in the face of a healthcare provider's duty to their employer and society at large when initiating care and assigning finite healthcare resources. An ethical framework is necessary to help guide healthcare providers in reference to the ethical treatment of electronic data and information during all stages of collection,

storage, manipulation, and dissemination. These new approaches and means come with their own ethical dilemmas. Often, they are dilemmas not yet faced owing to the cutting-edge nature of these technologies.

Just as processes and models are used to diagnose and treat patients in practice, so too a model in the analysis and synthesis of ethical dilemmas or cases can be applied. An ethical model for ethical decision-making (**Box 5-1**) facilitates the ability to analyze the dilemma and synthesize the information into a plan of action (McGonigle, 2000). The model presented here is based on the letters in the word *ethical*. Each letter guides and prompts the healthcare provider to think critically (i.e., think and rethink) through the situation presented. The model is a tool because in the final analysis, it allows the nurse to objectively ascertain the essence of the dilemma and develop a plan of action.

BOX 5-1 ETHICAL MODEL FOR ETHICAL DECISION-MAKING

- **E**xamine the ethical dilemma (conflicting values exist).
- **T**horoughly comprehend the possible **alternatives** available.
- **H**ypothesize ethical arguments.
- **I**nvestigate, compare, and evaluate the arguments for each alternative.
- **C**hoose the alternative you would recommend.
- **A**ct on your chosen alternative.
- **L**ook at the ethical dilemma and examine the outcomes while reflecting on the ethical decision.

APPLYING THE ETHICAL MODEL

Examine the ethical dilemma:

- Use your problem-solving, decision-making, and critical thinking skills.
- What is the dilemma you are analyzing? Collect as much information about the dilemma as you can, making sure to gather the relevant facts that clearly identify the dilemma. You should be able to describe in detail the dilemma you are analyzing.

- Ascertain exactly what must be decided.
- Who should be involved in the decision-making process for this specific case?
- Who are the interested players or stakeholders?
- Reflect on the viewpoints of these key players and their value systems.
- What do you think each of these stakeholders would like you to decide as a plan of action for this dilemma?
- How can you generate the greatest good?

Thoroughly comprehend the possible alternatives available:

- Use your problem-solving, decision-making, and critical thinking skills.
- Create a list of the possible alternatives. Be creative when developing your alternatives. Be open minded; there is more than one way to reach a goal. Compel yourself to discern at least three alternatives.
- Clarify the alternatives available and predict the associated consequences—good and bad—of each potential alternative or intervention.
- For each alternative, ask the following questions:
  - Do any of the principles or rules, such as legal, professional, or organizational, automatically nullify this alternative?
  - If this alternative is chosen, what do you predict as the best-case and the worst-case scenarios?
  - Do the best-case outcomes outweigh the worst-case outcomes?
  - Could you live with the worst-case scenario?
  - Will anyone be harmed? If so, how will they be harmed?
  - Does the benefit obtained from this alternative overcome the risk of potential harm that it could cause to anyone?

Hypothesize ethical arguments:

- Use your problem-solving, decision-making, and critical thinking skills.
- Determine which of the five approaches apply to this dilemma.
- Identify the moral principles that can be brought into play to support a conclusion as to what ought to be done ethically in this case or in similar cases.
- Ascertain whether the approaches generate converging or diverging conclusions about what ought to be done.

Investigate, compare, and evaluate the arguments for each alternative:

- Use your problem-solving, decision-making, and critical thinking skills.
- Appraise the relevant facts and assumptions prudently.
  - Is there ambiguous information that must be evaluated?

    - Are there any unjustifiable factual or illogical assumptions or debatable conceptual issues that must be explored?
- Rate the ethical reasoning and arguments for each alternative in terms of their relative significance.
    - 4 = extreme significance
    - 3 = major significance
    - 2 = significant
    - 1 = minor significance
- Compare and contrast the alternatives available with the values of the key players involved.
- Reflect on these alternatives:
    - Does each alternative consider all the key players?
    - Does each alternative consider and reflect an interest in the concerns and welfare of all the key players?
    - Which alternative will produce the greatest good or the least amount of harm for the greatest number of people?
- Refer to your professional codes of ethical conduct. Do they support your reasoning?

Choose the alternative you would recommend:

- Use your problem-solving, decision-making, and critial thinking skills.
- Decide which alternative available is the best.
    - Remember the Golden Rule: Does your decision treat others as you would want to be treated?
    - Does your decision consider and reflect an interest in the concerns and welfare of all the key players?
    - Does your decision maximize the benefit and minimize the risk for everyone involved?
- Become your own critic. Challenge your decision as you think others might. Use the ethical arguments you predict they would use and defend your decision.
    - Would you be secure enough in your ethical decision-making process to see it aired on national television or sent out globally over the internet?
    - Are you secure enough with this ethical decision that you could have allowed your loved ones to observe your decision-making process, your decision, and its outcomes?

Act on your chosen alternative:

- Use your problem-solving, decision-making, and critical thinking skills.

- Formulate an implementation plan delineating the execution of the decision.
  - This plan should be designed to maximize the benefits and minimize the risks.
  - This plan must consider all the resources necessary for implementation, including personnel and money.
- Implement the plan.

Look at the ethical dilemma and examine the outcomes while reflecting on your ethical decision:

- Use your problem-solving, decision-making, and critical thinking skills.
- Monitor the implementation plan and its outcomes. It is extremely important to reflect on specific case decisions and evaluate their outcomes to develop your ethical decision-making ability.
- If new information becomes available, the plan must be reevaluated.
- Monitor and revise the plan as necessary.

The ethical model for ethical decision-making was developed by Dr. Dee McGonigle and is the property of Educational Advancement Associates (EAA). The permission for its use in this text has been granted by Mr. Craig R. Goshow, Vice President, EAA.

Case Analysis Demonstration

The following case study is intended to help readers think through how to apply the ethical model. Review the model and then read through the case. Try to apply the model to this case or follow along as the model is implemented. Readers are challenged to determine their decision in this case and then compare and contrast their response with the decision the authors reached.

> *Allison is a charge nurse on a busy medical–surgical unit. She is expecting the clinical instructor from the local university at 2:00 p.m. to review and discuss potential patient assignments for the nursing students scheduled for the following day. Just as the university professor arrives, one of the patients on the unit develops a crisis requiring Allison's attention. To expedite the student nurse assignments for the following day, Allison gives her electronic medical record access password to the instructor.*

Examine the Ethical Dilemma

Allison made a commitment to meet with the university instructor to develop student assignments at 2:00 p.m. The patient emergency that developed prevented Allison from living up to that commitment. Allison had an obligation to provide patient care during the emergency and a competing obligation to the professor. She solved the dilemma of competing obligations by providing her electronic medical record access password to the university professor.

By sharing her password, Allison most likely violated hospital policy related to the **security** of healthcare information. She may also have violated the American Nurses Association code of ethics, which states that nurses must judiciously protect information of a confidential nature. Because the university professor was also a nurse and had a legitimate interest in the protected healthcare information, there might not be a code of ethics violation.

Thoroughly Comprehend the Possible Alternatives Available

The possible alternatives available include the following: (1) Allison could have asked the professor to wait until the patient crisis was resolved, (2) Allison could have delegated another staff member to assist the university professor, or (3) Allison could have logged on to the system for the professor.

Hypothesize Ethical Arguments

The utilitarian approach applies to this situation. An ethical action is one that provides the greatest good for the greatest number; the underlying principles in this perspective are beneficence and nonmaleficence. The rights to be considered are as follows: right of the individual to choose for themselves (autonomy), right to **truth** (veracity), right of privacy (the ethical right to privacy avoids conflict and, like all rights, promotes harmony), right not to be injured, and right to what has been promised (fidelity).

Does the action respect the **moral rights** of everyone? The principles to consider are autonomy, veracity, and fidelity.

As for the fairness or justice, how fair is an action? Does it treat everyone in the same way, or does it show favoritism and discrimination? The principles to consider are justice and distributive justice.

Thinking about the common good assumes one's own good is inextricably linked to the good of the community; community members are bound by pursuit of common values and goals and ensuring that the social policies, social systems, institutions, and environments on which one depends are beneficial to all. Examples of such outcomes are affordable health care, effective public safety, a just legal system, and an unpolluted environment. The principle of distributive justice is considered.

Virtue assumes that one should strive toward certain ideals that provide for the full development of humanity. Virtues are attitudes or

character traits that enable one to be virtuous and to act in ways that develop the highest potential. Examples include honesty, courage, compassion, generosity, fidelity, integrity, fairness, self-control, and prudence. Like habits, virtues become characteristics of the person. The virtuous person is the ethical person. Ask yourself, what kind of person should I be? What will promote the development of character within myself and my community? The principles considered are fidelity, veracity, beneficence, nonmaleficence, justice, and distributive justice.

In this case, there is a clear violation of an institutional policy designed to protect the privacy and confidentiality of medical records. However, the professor had a legitimate interest in the information and a legitimate right to the information. Allison trusted that the professor would not use the system password to obtain information outside the scope of the legitimate interest. However, Allison cannot be sure that the professor would not access inappropriate information. Further, Allison is responsible for how her access to the electronic system is used. Balancing the rights of everyone—the professor's right to the information, the patients' rights to expect that their information is safeguarded, and the right of the patient in crisis to expect the best possible care—is important and is the crux of the dilemma. Does the patient care obligation outweigh the obligation to the professor? Yes, probably. Allison did the right thing by caring for the patient in crisis. By giving out her system access password, Allison also compromised the rights of the other patients on the unit to expect that their confidentiality and privacy would be safeguarded.

Virtue ethics suggests that individuals use power to bring about human benefit. One must consider the needs of others and the responsibility to meet those needs. Allison must simultaneously provide care, prevent harm, and maintain professional relationships.

Allison may want to effect a long-term change in hospital policy for the common good. It is reasonable to assume that this event was not an isolated incident and that the problem may recur in the future. Can the institutional policy be amended to provide professors with access to the medical records system? As suggested in the

HIPAA administrative guidelines, the professor could receive the same staff training regarding appropriate and inappropriate use of access and sign the agreement to safeguard the records. If the institution has tracking software, the professor's access could be monitored to watch for inappropriate use.

Identify the moral principles that can be brought into play to support a conclusion as to what ought to be done ethically in this case or in similar cases. The International Council of Nurses (2020) code of ethics states, "The nurse holds in confidence personal information and uses judgment in sharing this information" (p. 2). The code also states, "The nurse uses judgment in relation to individual competence when accepting and delegating responsibilities" (p. 5). Both of these statements apply to the current situation.

Ascertain whether the approaches generate converging or diverging conclusions about what ought to be done. From the analysis, it is clear that the best immediate solution is to delegate assisting the professor with assignments to another nurse on the unit.

Investigate, Compare, and Evaluate the Arguments for Each Alternative

Review and think through the items listed in **Table 5-1**.

TABLE 5-1 Detailed Analysis of Alternative Actions

Alternative	Good Consequences	Bad Consequences	Do Any Rules Nullify?	Expected Outcome	Potential Benefit > Harm
1. Wait until the crisis is resolved	No policy violation Patient rights safeguarded	Not the best use of the professor's time	No	Best: Crisis will require a short time Worst: Crisis may take a long time	Patient rights protected Collegial relationship jeopardized Patient rights may take precedence
2. Delegate to another staff member	No policy violation	Other staff may be equally busy or might not be as familiar with all patients	No	Best: Assignments will be completed Worst: May not have benefit of expert advice	Confidentiality of records is assured May compromise student learning Patient rights may take precedence
3. Log on to the system for the professor	Professor can begin making assignments	May still be a violation of policy regarding system access	Rules regarding access to medical records	Best: Assignments can be completed Worst: Abuse of access to information	Potential compromise of records Patient in crisis is cared for

Description

Choose the Alternative You Would Recommend

The best immediate solution is to delegate another staff member to assist the professor. The best long-term solution is to change the hospital policy to include access for professors, as described previously.

Act on Your Chosen Alternative

Allison should delegate another staff member to assist the professor in making assignments.

Look at the Ethical Dilemma and Examine the Outcomes While Reflecting on the Ethical

Decision

As already indicated in the alternative analyses, delegation may not be an ideal solution because the staff nurse who is assigned to assist the professor may not possess the same extensive information about all the patients as the charge nurse. It is, however, the best immediate solution to the dilemma and is certainly safer than compromising the integrity of the hospital's computer system. As noted previously, Allison may want to pursue a long-term solution to a potentially recurring problem by helping the professor gain legitimate access to the computer system with the professor's own password. The system administrator would then have the ability to track who used the system and which types of information were accessed during use.

This case analysis demonstration provides the authors' perspective on this case and the ethical decision made. If your decision did not match this perspective, what was the basis for the difference of opinion? If you worked through the model, you might have reached a different decision based on your individual background and perspective. This does not make the decision right or wrong. A decision should reflect the best decision one can make given review, reflection, and critical thinking about this specific situation.

Six additional cases are provided in the online learner's manual for review. Apply the model to each case study, and discuss these cases with colleagues or classmates.

New Frontiers in Ethical Issues

The expanding use of new information technologies in health care will bring about new and challenging ethical issues. Consider that patients and healthcare providers no longer have to be in the same place for a quality interaction. How, then, does one deal with licensing issues if the electronic consultation takes place across a state line? Derse and Miller (2008) described a second opinion medical consultation on the internet where the information was provided to the referring physician and not to the patient, thus avoiding the licensing issue. In essence, provider-to-provider consultation does not constitute practicing in a state in which you are not licensed. As new technologies for healthcare delivery are developed, new ethical challenges may arise. It is important for all healthcare providers to be aware of the code of ethics for their specific practices and to understand the laws governing their practice and private health information.

Consider also the ethical issues created by genomic databases or by the sharing of information in a health information exchange to promote population health. Alpert (2008) asked, "Is it wise to put genomic sequence data into electronic medical records that are poorly protected, that cannot adhere well to Fair Information Practice Principles for privacy, and that can potentially be seen by tens of thousands of people/entities, when it is clear that we do not understand the functionality of the genome and likely will not for several years?" (p. 382). That was the ethical consideration about the genome then, but what about now? What should we be concerned about?

Further, how does one really obtain informed consent for such data collection when how the data will ultimately be used is not known but clearly that application will be important to health research uses that go beyond the immediate medical care of the patient? Angst (2009) asked whether the public good outweighs individual interests in such a case because the information contained

in these databases is important to developing new understandings and creating new knowledge by matching data in aggregated pools: “Thus, science adds meaning and context to data, but to what extent do we agree to make the data available such that this discovery process can take place, and are the impacts of discovery great enough to justify the risks?” (p. 172). Further, if a voluntary system for which patients can opt out of such data collection is adopted, then are healthcare disparities related to incomplete electronic health records created?

In an ideal world, healthcare professionals must not be affected by conflicting loyalties; nothing should interfere with judicious, ethical decision-making. As the technologically charged waters of health care are navigated, one must hone a solid foundation of ethical decision-making, practice it, and reevaluate it consistently.

Summary

As science and technology advance and policymakers and healthcare providers continue to shape healthcare practices, including information management, it is paramount that ethical decisions be made. Healthcare professionals are typically honest, trustworthy, and ethical, and they understand that they are duty bound to focus on the needs and rights of their patients. At the same time, their day-to-day work is conducted in a world of changing healthcare landscapes populated by new technologies; diverse patients; varied healthcare settings; and changing policies set by their employers, insurance companies, and providers. The technologies themselves are not the problem, but their misuse can cause harm to our patients. If we use them to the patient's advantage while protecting the patient, they can be beneficial tools in accessing our technologically savvy patients to garner the data and information necessary to address their healthcare needs, including patient education, while impacting public health and enhancing our relationship with our patients. Healthcare professionals need to juggle all these balls simultaneously, and so the ethical considerations must be at the forefront, a task that often results in far too many gray areas or ethical decision-making dilemmas with no clear correct course of action. Patients rely on the ethical competence of their healthcare providers, believing that their situation is unique and will be respected and evaluated based on their own needs, abilities, and limitations. The healthcare professional cannot allow conflicting loyalties to interfere with judicious, ethical decision-making. Just as in the opening example of the *Apollo* mission, it is uncertain where this technologically heightened information era will lead, but if a solid foundation of ethical decision-making is relied upon, duties and rights will be judiciously and ethically fulfilled.

THOUGHT-PROVOKING QUESTIONS

1. Identify moral dilemmas in healthcare informatics that would best be approached with the use of an ethical decision-making framework, such as the use of smartphones to interact with patients as well as to monitor and assess patient health.
2. Discuss the evolving healthcare ethics traditions within their social and historical contexts.
3. Differentiate among the theoretical approaches to healthcare ethics as they relate to the theorists' perspectives of individuals and their relationships.
4. Select one of the healthcare ethics theories and support its use in examining ethical issues in healthcare informatics.
5. Select one of the healthcare ethics theories and argue against its use in examining ethical issues in healthcare informatics.

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SECTION II
Perspectives on Nursing Informatics

Chapter 6 History and Evolution of Nursing Informatics

Chapter 7 Nursing Informatics as a Specialty

Chapter 8 Legislative Aspects of Nursing Informatics: HIPAA, HITECH, and Beyond

Nursing informatics (NI) is the synthesis of nursing science, information science, computer science, and cognitive science for the purpose of managing and enhancing healthcare data, information, knowledge, and wisdom to improve patient care and the nursing profession. In Section I, *Building Blocks of Nursing Informatics*, the reader learned about the four sciences of NI, also referred to as the four building blocks, and the ethical application of these sciences to manage patient information. Nursing knowledge workers must be able to understand the evolving specialty of NI to harness and use the tools available for managing the vast amount of healthcare data and information. It is essential that NI capabilities be appreciated, promoted, expanded, and advanced to facilitate the work of the nurse, improve patient care, and enhance the nursing profession.

This section presents an overview of NI, informatics education and competencies, informatics as a specialty practice, and legislation that governs informatics and healthcare technology. Chapter 6, *History and Evolution of Nursing Informatics*, begins this exploration by providing the historical development and evolution of NI, which transitions into Chapter 7, *Nursing Informatics as a Specialty*, in which the reader learns about NI roles, competencies, and skills. Chapter 8, *Legislative Aspects of Nursing Informatics: HIPAA, HITECH, and Beyond*, considers the evolving NI needs of nurses and nurse informaticists, based on the current regulations affecting the healthcare arena.

In Chapter 6, *History and Evolution of Nursing Informatics*, interrelationships among major NI concepts are discussed. As data are transformed into information and information into knowledge, increasing complexity and interrelationships ensue. The boundaries between concepts can become blurred, and feedback loops from one concept level to another evolve. Structured languages and human–computer interaction concepts, which are critical elements for NI, are noted in this chapter. Taxonomies and other current structured languages for nursing are listed. Human–computer interaction concepts are briefly defined and discussed because they are critical to the success of informatics solutions. Importantly, the construct of decision-making is added to the traditional nursing metaparadigms: nurse, person, health, and environment. Decision-making is not only at the crux of nursing practice in all settings and roles but is also a fundamental concern of NI. The work of nursing is centered on the concepts of NI: data, information, knowledge, and wisdom. Information technology (IT) per se is not the focus. Instead, the focus is on the information that the technology conveys. Moreover, NI is no longer the domain of experts in the IT field. More interesting, one does not need technology to perform informatics. The centerpiece of informatics is the manipulation of data, information, and knowledge, especially related to decision-making in any aspect of nursing or in any setting. In a way, all nurses are already informatics nurses. Note that the core concepts and competencies of informatics are particularly well suited to a model of interprofessional education. Ideally, when educational programs are emulating clinical settings, informatics knowledge should be integrated with the processes of interprofessional teams and decision-making. Because simulation laboratories are becoming increasingly common fixtures in the delivery of health-related professional education, they provide a perfect opportunity to incorporate the electronic health record (EHR) applications. The learning laboratory for nursing education will then more closely approximate the IT-enabled clinical settings that are emerging in the real world. A presumption is often made that future graduates will be more computer literate than nurses currently in practice.

Although this may be true, computer literacy, or the comfort level someone has with using computer programs and applications, does not equate to an understanding of the facilitative and transformative role of IT. It is essential that the future curricula of basic nursing programs embed the concepts of the role of IT in supporting clinical care delivery. The need for standardizing nursing terminology is also discussed in this chapter as a way to improve the clinical support functions of the EHR. The healthcare industry employs the largest number of knowledge workers—a fact that has resulted in the realization that healthcare administrators must begin to change the way they look at their employees. Nurses and physicians are bright, highly skilled, and dedicated to giving the best patient care. Administrators who tap into this wealth of knowledge find that patient care becomes safer and more efficient.

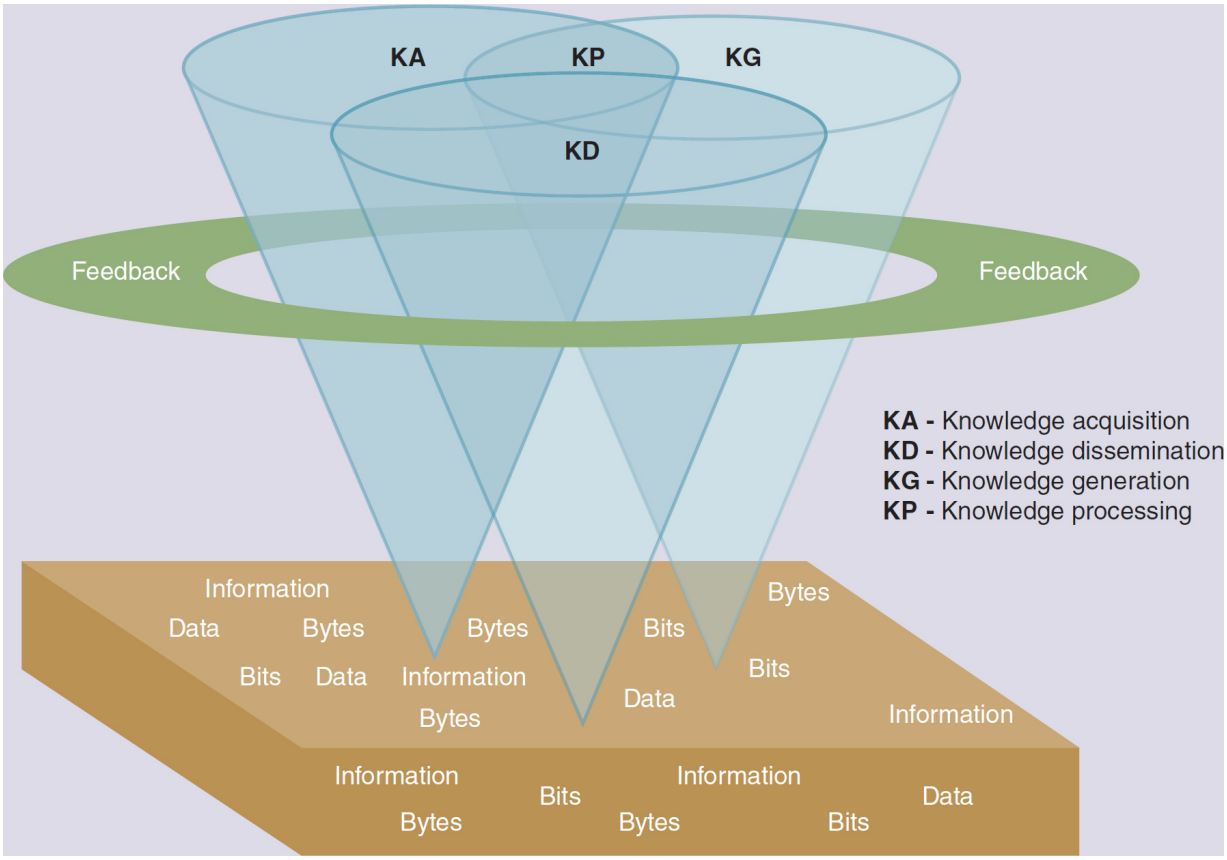
Chapter 7, *Nursing Informatics as a Specialty*, discusses NI as a relatively new nursing specialty that combines the building block sciences covered earlier in the text. Combining these sciences results in nurses being able to care for their patients effectively and safely because the information that they need is readily available. Nurses have been actively involved in NI since computers were introduced into health care. With the advent of EHRs, it became apparent that nursing needed to develop its own language for this evolving field. NI was instrumental in assisting in nursing language development. NI is governed by standards established by the American Nurses Association and is a very diverse field, which results in many nurse informaticist specialists becoming focused on one segment of NI. Although NI is a recognized specialty area of practice, in the future all nurses will be expected to have some knowledge of the field, as discussed in Chapter 6, *History and Evolution of Nursing Informatics*. NI competencies have been developed to ensure that all entry-level nurses are ready to enter a field that is becoming more technologically advanced. The competencies may also be used to determine the educational needs of currently practicing nurses as well as NI specialists. NI specialists no longer must enter the field solely through on-the-job exposure but can now obtain an advanced

degree in NI at many well-established universities throughout the United States. NI has grown tremendously as a specialty since its inception and is predicted to continue growing.

Chapter 8, *Legislative Aspects of Nursing Informatics: HIPAA, HITECH, and Beyond*, provides insights into the Health Insurance Portability and Accountability Act (HIPAA) rules and an overview of the rules associated with technology implementation as defined by the Health Information Technology for Economic and Clinical Health (HITECH) Act. Equally important in informatics practice is a thorough understanding of current legislation and regulations that shape 21st-century practice. The information provided in this text reflects current rules that were in effect at the time of publication. The reader should follow the development of rules and the evolution of informatics legislation at the U.S. Department of Health and Human Services website (www.hhs.gov) to obtain the most current information related to health information management.

There is an emerging global focus on IT to support clinical care and on the potential benefits for clinicians and patients. In the future, nurses will likely have sufficient computing power at their disposal to aggregate and transform additional multidimensional data and information sources (e.g., historical, multisensory, experiential, and genetic) into a clinical information system to engage with individuals, families, and groups in ways not yet imagined. Every nurse's practice will make contributions to new nursing knowledge in these dynamically interactive clinical information system environments. With the right tools to support the management of data, complex information processing, and ready access to knowledge, the core concepts and competencies associated with informatics will be embedded in the practice of every nurse, whether administrator, researcher, educator, or practitioner. IT is not a panacea, but it provides the profession with unprecedented capacity to generate and disseminate new knowledge more rapidly.

The material in this text is placed within the context of the Foundation of Knowledge model (**Figure II-1**) to meet the needs of healthcare delivery systems, organizations, patients, and nurses. Through involvement in NI and learning about this evolving specialty, one will be able to use the current theories, architecture, and tools while beginning to challenge what is known. This questioning and search for what could be will provide the basis for the future landscape of nursing. By using the Foundation of Knowledge model as an organizing framework for this text, the authors have attempted to capture this process.



Designed by Alicia Mastrian

Figure II-1 Foundation of Knowledge Model

Description

In this section, readers learn about NI. Those readers who are beginning their education will consciously focus on input and knowledge acquisition to glean as much information and knowledge as possible. As these readers become more comfortable in their clinical setting and with nursing science, they will begin to perform some of the other knowledge functions. Experienced nurses, also known as seasoned nurses, question what is known and search for ways to enhance their knowledge and the knowledge of others. What is not available must be created. Through these leaders, researchers, or clinicians, new knowledge is generated and disseminated, and nursing science is advanced. Sometimes, however, to keep up with the explosion of information in nursing and health care, one must continue to rely on the knowledge generated and disseminated by others. In this sense, nurses are committed to lifelong learning and the use of knowledge in the practice of nursing science. How nurses interact within their environment and apply what is learned denotes where they are in the ongoing process captured in the Foundation of Knowledge model; they can be acquiring knowledge, processing knowledge, generating knowledge, and/or disseminating knowledge.

Readers of this section are challenged to ask how they can (1) apply knowledge gained from the practice setting to benefit patients and enhance their practice; (2) help colleagues and patients understand and use current technology; and (3) use wisdom to help create the theories, tools, and knowledge of the future.



CHAPTER 6

History and Evolution of Nursing Informatics

OBJECTIVES

1. Trace the evolution of nursing informatics from concept to specialty practice.
2. Relate nursing informatics metastructures, concepts, and tools to the knowledge work of nursing.
3. Explore the quest for consistent terminology in nursing, and describe terminology approaches that accurately capture and codify the contributions of nursing to health care.
4. Explore informatics education initiatives.
5. Explore how nurses can create and derive clinical knowledge from information systems.

KEY TERMS

- accessibility
- data
- data gatherer
- enumerative approach
- expert system
- information
- information user
- International Classification of Nursing Practice (ICNP)
- knowledge

- knowledge builder
- knowledge user
- knowledge worker
- ontological approach
- reusability
- standardized nursing terminology
- terminology
- ubiquity
- wisdom

Introduction

The information and knowledge that inform 21st-century healthcare delivery have been growing at an unprecedented pace in recent years. Clinical research has propelled the understanding of the efficacy of various clinical practices, treatment regimens, and interventions. Extended and expanded access to clinical research findings and decision support tools has been significantly influenced by the advent of computerization and the internet. Indeed, the conduct of research itself has been accelerated by virtue of ubiquitous computing. Working in environments of increasingly complex clinical care and contending with the management of large volumes of data and information, all nurses need to avail themselves of the technological tools that can support quality practice that is optimally safe, informed, and knowledge based. Although the increased deployment of information technology (IT) within healthcare settings presumes that nurses and other health professionals are proficient in the use of computing devices, the processes and potential outcomes associated with informatics are yet to be fully realized or understood. Nurses need to participate in the creation of those possibilities.

Health service organizations, societies, and governments throughout the industrialized world are committed to ensuring that healthcare delivery is safe, knowledge based, cost-effective, seamless, and timely. Beyond these deliverables, there are expectations of improved efficiency and quality and of the active engagement of consumers in their care. Given the evolving emphasis on such issues as chronic disease management and aging at home, informatics tools need to include the use of technologies to empower citizens to manage their own health and wellness more effectively.

This chapter explores the history and evolution of nursing informatics (NI) and informatics education and defines and addresses the goal of informatics as it relates to nursing practice. The ways in which NI supports the creation of a culture of

knowledge-based nursing practice that is enabled and advanced using information and communication technologies are described. The chapter also addresses some of the challenges associated with the attainment of this knowledge-based culture as well as the opportunities for nurses to create and derive knowledge from emerging health IT. Finally, the chapter provides a contemplative view of the future for nurses and informatics.

The Evolution of a Specialty

Nurses have historically gathered and recorded data, albeit in a paper record. For example, nurses gather atomic-level data (e.g., blood pressure, pulse, blood glucose, and pallor), aggregate data to derive information (e.g., impending shock), and apply knowledge (e.g., implement the evidence-based practice [EBP] protocol for impending shock). Over the years, these data have been recorded into individuals' hard copy health records, thereby chronicling findings, actions, and outcomes; these data and information were then forever lost, unless they were manually extracted for research purposes. As computers were introduced into health care and data and information were recorded electronically, a nursing specialty was born.

Florence Nightingale has been credited as one of the first statisticians to collect and use data to change the way she cared for her patients. While serving in the Crimean War, she began to gather data regarding the conditions in which patients were living and the diseases they contracted and from which they died. These data were later used to improve patient conditions at both city and military hospitals (O'Connor & Robertson, 2003). There is no doubt that nursing experiences build knowledge and skill in nursing practice but that paper-based documentation has hindered the ability to share knowledge and aggregate experiences to build new knowledge.

NI pioneers recognized early on that computers had the potential to fundamentally change health care, and they became actively involved in shaping how computers were used in health care. For more specific information on NI pioneers and to view video recordings of the contributions of each pioneer in the NI history project, please visit this website: https://amia.org/community/working-groups/nursing-informatics/nursing-informatics-innovators.

According to Ozbolt and Saba (2008), one very early pioneer, Harriet Werley, a nurse researcher at Walter Reed Army Research

Institute, consulted with IBM in the late 1950s to explore computer use in health care. Ms. Werley recognized the need for a minimum set of data to be collected from every patient so that comparisons could be made, which set the stage for the development of informatics. As computers became more commonplace in the 1970s and 1980s, more nurses became involved with developing approaches to using computers in health care. It is important to note that this was also the time when nurse leaders were writing about the need for and developing terminologies to represent patient data and nursing contributions to health care, beginning to conduct informatics research, and advocating for informatics education in nursing curricula (Ozbolt & Saba, 2008).

In 1989, Graves and Corcoran offered what is widely viewed as the seminal definition of NI. They defined NI as "a combination of computer science, information science, and nursing science designed to assist in the management and processing of nursing data, information, and knowledge to support the practice of nursing and the delivery of nursing care" (p. 227). In this same article, acknowledging the 1986 work of Blum, Graves and Corcoran provided the definitions and descriptions of the concepts of data (i.e., discrete entities described objectively without interpretation), information (i.e., data that are interpreted, organized, or structured), and knowledge (i.e., information that is synthesized so that relationships are identified and formalized) as they apply to the science and practice of NI. They also described what is meant by management and processing:

> *The management component of informatics is the functional ability to collect, aggregate, organize, move, and re-present information in an economical, efficient way that is useful to the users of the system. . . . In practice, processing is considered as a transformation of data or information from one form to another form, usually at a more complex state of organization or meaning. There is a progression of transformation of data into information and of information into knowledge.* (p. 227)

We will return to a discussion of these concepts later in the chapter. For now, we continue our exploration of the evolution of informatics

as a specialty.

In the 1990s, an NI workgroup was established within the newly founded American Medical Informatics Association, the American Nurses Association (ANA) recognized NI as a specialty and published two documents related to informatics practice, and the first informatics certification was established (Ozbolt & Saba, 2008). As NI pioneers and emerging leaders continued to champion the use of computers in health care, the need for computer-friendly terminologies to represent the work of nursing was increasingly apparent. Several **terminology** schemes were developed during this time, and there were also international efforts at developing a standardized nursing terminology to capture and codify the contributions of nursing to health care. At the same time, healthcare organizations were beginning to implement electronic information systems. There was much work being done around computerization in health care, but there was little coordination of these efforts and approaches. Ozbolt and Saba (2008) explained that the cost of using known nomenclatures and the difficulty in choosing among them resulted in many healthcare organizations deciding to use their own or vendor-provided, nonstandard terms. Use of nonstandard terms creates issues with data retrieval and analysis. We will discuss this issue in more detail later in the chapter.

President George W. Bush's call for electronic health records (EHRs) in 2004 further stimulated the development of NI, informatics competency identification, and informatics education reform and spawned several national and international informatics organizations. Knowledge creation in nursing is dependent on knowledge representation in the information management tools that are central to NI, thus we see the clear connection between nursing science and NI. That is, knowledge creation in nursing is dependent on knowledge representation in the information management tools that are central to NI. As the NI pioneers recognized these important connections and synergies, both nursing as a science and NI as a specialty evolved. Indeed, the evolution is not complete.

As the NI specialty was evolving, informatics pioneers and other nurse leaders collaborated on several ANA publications. As

mentioned previously, NI was identified by the ANA as a specialty in 1992. In 1994, the first formal document identifying the scope of practice was published, followed by a separate standards of practice document in 1995. In 2001, a combined scope and standards document was published by the ANA, followed by a more robust scope and standards publication in 2008. In 2015, the ANA released the second edition of *Nursing Informatics: Scope and Standards of Practice*, and in 2022, the third edition was released.

What Is Nursing Informatics?

The definition of NI has undergone several revisions to arrive at its current form. The 1994 ANA definition of NI indicated that it was the integration of nursing science, computer science, and information science and that it supports practice, education, research, and knowledge development (Murphy, 2010). The 2001 version mentioned the support of decision-making by patients and providers across all roles and settings and identified information structures, processes, and IT as central to informatics (Murphy, 2010). An important change in the 2008 definition of NI is the addition of wisdom to the key concepts of the management of data, information, and knowledge (Murphy, 2010).

The ANA's *Nursing Informatics: Scope and Standards of Practice* (2015) offered the following definition of NI:

> *Nursing informatics (NI) is the specialty that integrates nursing science with multiple information and analytical sciences to identify, define, manage, and communicate data, information, knowledge, and wisdom in nursing practice. NI supports nurses, consumers, patients, the interprofessional healthcare team, and all other stakeholders in their decision-making in all roles and settings to achieve desired outcomes. This support is accomplished through the use of information structures, information processes, and information technology.* (pp. 1–2)

In the 2015 version, we note that the sciences are no longer limited to nursing science, information science, and computer science. Cognitive science is also a very important part of NI. Other sciences that may contribute to NI include library science and information management, mathematics, archival science, and the science of terminologies and taxonomies (ANA, 2015).

Let us reflect more carefully on NI by deconstructing each of the statements contained in the ANA's (2015) definition (statements from the definition are italicized):

- *Nursing informatics (NI) is the specialty that integrates nursing science with multiple information and analytical sciences to identify, define, manage, and communicate data, information, knowledge, and wisdom in nursing practice.* As we established previously, there are concepts drawn from several sciences that are integrated to support and contribute to NI. The contributions of these sciences become apparent in the actions of NI: identify, define, manage, and communicate. The last part of this statement contains the critical central concepts of NI: the data, information, knowledge, and wisdom that are integral to our practice. We will explore these central concepts in more detail in the next section.
- *NI supports nurses, consumers, patients, the interprofessional healthcare team, and all other stakeholders in their decision-making in all roles and settings to achieve desired outcomes.* This statement refers to the IT tools that support our practice and help us to collaborate and communicate with other healthcare professionals and that support the evolving trends and tools related to patient engagement in managing their own health. All these tools contribute to better health outcomes. Examples of such tools are EHRs, barcode medication administration systems, clinical decision support and other expert systems, patient monitoring devices, and telehealth tools. These and other NI tools are discussed in subsequent chapters.
- *This support is accomplished through the use of information structures, information processes, and information technology.* This section of the definition clearly identifies the need for IT to provide structure to the data we collect from our patients and to allow for processing of data and information to create knowledge and support wisdom in nursing practice. Think about the fact that with the advent of clinical information systems (CISs), specifically electronic documentation and clinical decision support (CDS) applications, every nurse has the capacity to contribute to the advancement of nursing knowledge on many levels. Imagine the use of IT solutions to capture not only

> discrete, quantifiable data but also the nurse's experiential and intuitive personal knowledge not typically documented in paper records. Add to that mix the family history, culture, environmental and social factors, past experiences, and perspectives from patients and families, and it becomes clear that the possibilities for generating new understandings within populations and across the life span and care continuum are endless. Many of these technologies are covered in subsequent chapters.

In 2022, the ANA released the third edition of *Nursing Informatics: Scope and Standards of Practice.* The third edition is described as "the culmination of a 2-year intensive professional review and revision initiative, complicated by the significant interruptions of the Covid-19 pandemic in 2020 and 2021" (ANA, 2022, p. 1). The ANA offers this current definition of NI:

> *Nursing informatics is the specialty that transforms data into needed information and leverages technologies to improve health and health care equity, safety, quality, and outcomes*. (ANA, 2022, p. 3)

We shall examine the essence of NI in detail in subsequent chapters.

The DIKW Paradigm

The conceptual framework underpinning the science and practice of NI centers on the core concepts of data, information, knowledge, and wisdom, also known as the DIKW paradigm. As an aside, it is important to note that this paradigm is not exclusive to nursing and that it is in fact used by others who work with data and information. When we assess a patient to determine their nursing needs, we gather and then analyze and interpret data to form a conclusion. This is the essence of nursing science. Information is composed of data that were processed using knowledge. Knowledge is the awareness and understanding of a set of information and the ways that information can be made useful to support a specific task or arrive at a decision. When we apply previous knowledge to data, we convert those data into information and information into new knowledge—that is, an understanding of which interventions are appropriate in practice. Thus, information is data made functional through the application of knowledge. Wisdom is the appropriate application of knowledge to a specific situation. In the practice of nursing science, one expects actions to ultimately be directed by wisdom. Wisdom uses knowledge and experience to heighten common sense and insight to exercise sound judgment in practical matters.

Matney et al. (2011) and Topaz (2013) provided these expanded definitions and examples of the DIKW paradigm:

- *Data*: **Data** are the smallest components of the DIKW framework. They are commonly presented as discrete facts, the product of observation with little interpretation (Matney et al., 2011). These are the discrete factors describing the patient or their environment. Examples include the patient's medical diagnosis (e.g., International Classification of Diseases [ICD-10] diagnosis #150.20: Unspecified systolic [congestive] heart failure) or living status (e.g., living alone, living with family, or

living in a retirement community). A single piece of data, known as datum, often has little meaning in isolation.

- *Information*: **Information** might be thought of as "data + meaning" (Matney et al., 2011). Information is often constructed by combining data points into a meaningful picture given a certain context. Information is a continuum of progressively developing and clustered data; it answers questions such as who, what, where, and when. For example, a combination of a patient's "ICD-10 diagnosis #150.20: Unspecified systolic (congestive) heart failure" and living status "living alone" has a certain meaning in the context of an older adult.
- *Knowledge*: **Knowledge** is information that has been synthesized so that relations and interactions are defined and formalized; it is built of meaningful information constructed of discrete data points (Matney et al., 2011). Knowledge is often affected by assumptions and central theories of a scientific discipline and is derived by discovering patterns of relationships among clusters of information. Knowledge answers questions of why or how. For healthcare professionals, the combination of information clusters, such as the "ICD-10 diagnosis #150.20: Unspecified systolic (congestive) heart failure" plus living status "living alone," with additional information that an older man (78 years old) was just discharged from the hospital to home with a complicated new medication regimen (e.g., blood thinners) might indicate that this person is at a high risk for drug-related adverse effects (e.g., bleeding).
- *Wisdom*: **Wisdom** is an appropriate use of knowledge to manage and solve human problems (ANA, 2008; Matney et al., 2011). Wisdom implies a form of ethics, or knowing why certain things or procedures should or should not be implemented in healthcare practice. In nursing, wisdom guides the nurse in recognizing the situation at hand, based on the patient's values and the nurse's experience and healthcare knowledge. Combining all these components, the nurse decides on a nursing intervention or action. Benner (2000) presents wisdom as a

> clinical judgment that integrates intuition, emotions, and the senses. Using the previous examples, wisdom would be displayed when the home care nurse considers prioritizing the elderly heart failure patient who is using blood thinners for an immediate intervention, such as an initial nursing visit within the first hours of discharge from the hospital to ensure appropriate use of medications (para. 2).

Reflect on the examples previously given by Topaz, and create your own example of an application of the DIKW scenario.

The DIKW paradigm is frequently depicted as a pyramid, which suggests a hierarchy, with data on the bottom, then information, then knowledge, and finally wisdom. With the use of IT solutions to harvest and mine data to extract meaning, this depiction does not really reflect reality. Rowley (2007) suggested that alternate representations might better capture the complexity of these concepts. "Is there a sharp divide between data, information and knowledge, or do they lie on a continuum with different levels of meaning, structure, and actionability occurring at different levels?" (p. 175). Ronquillo et al. (2016) reported that the critiques of the hierarchical DIKW model centered around the suggested linearity and unidirectionality of movement from data to information to knowledge to wisdom. We offer **Figure 6-1**, which depicts the iterative, or repetitive, nature of our ability (both human and machine) to process data and information to build knowledge and sometimes reach wisdom. There is constant critical thinking (and processing) between information and knowledge. Knowledge can be eventually used to gain wisdom. We believe that most of the critical thinking, analysis, and synthesis occurs between data, information, and knowledge, with some extending to wisdom. The processing of data does not always end with wisdom because of the high degree of human agency in wisdom, but it will end in knowledge that provides a basis for action. As we enhance our knowledge and gain wisdom, the way we process, analyze, synthesize, and disseminate data, information, and knowledge evolves. The result is sound clinical judgment.

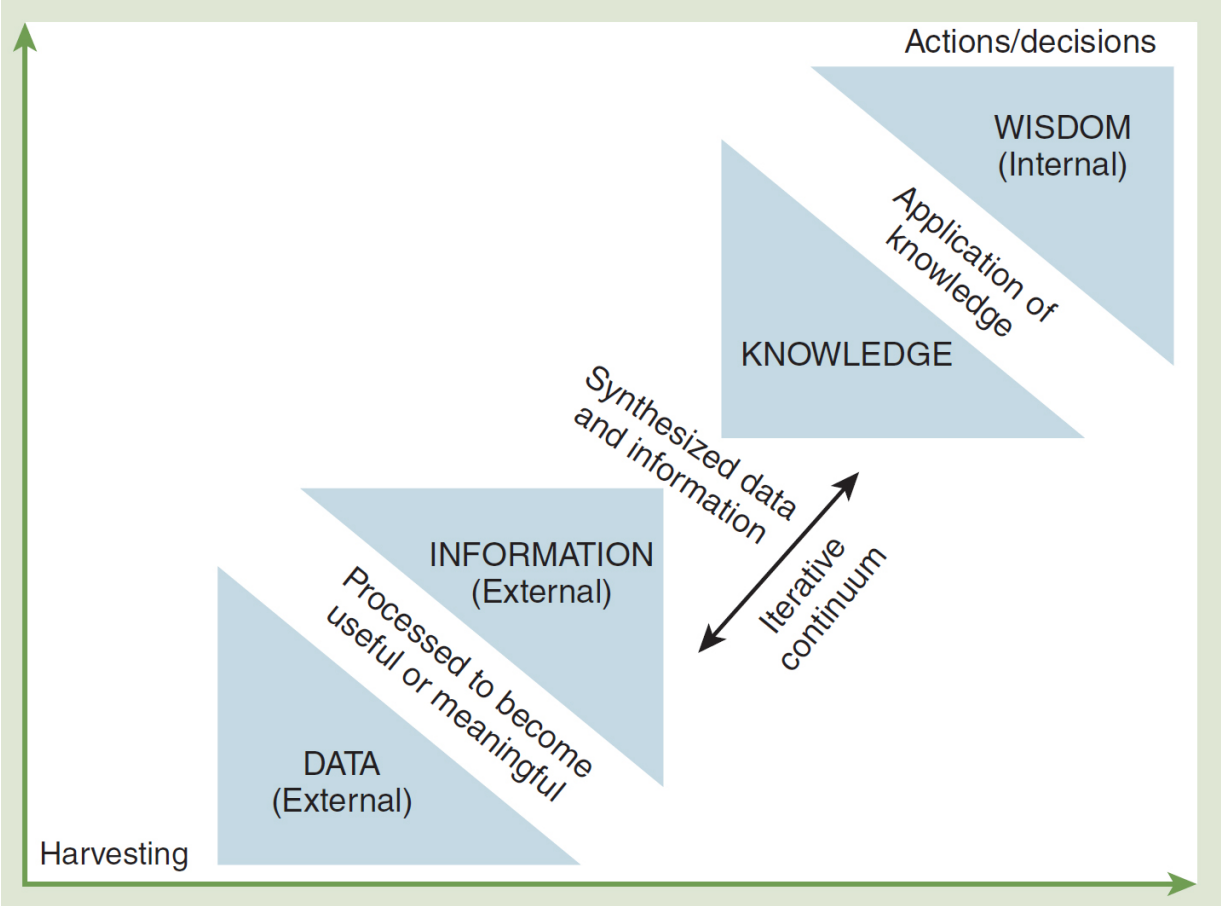


Figure 6-1 Moving From Data and Information to Knowledge and Wisdom

Description

Rowley (2007) was among the first to map data, information, knowledge, and wisdom to types of IT systems, which suggests that data reside in transaction processing systems; information, in information processing systems; knowledge, in decision support systems (DSSs); and wisdom, in expert systems. As IT tools become more sophisticated, we may gain more insight into how knowledge and wisdom are evolved from data and information. Because of the speed of processing and multiple iterations performed by these sophisticated tools, the lines between data, information, knowledge, and wisdom will be increasingly blurred. What really matters, though, is that the outcomes of this processing will provide important actionable insights to drive nursing practice.

Snyder-Halpern and colleagues (2001) identified four tasks associated with human information processing: (1) data gathering, (2) information use, (3) creative application of knowledge to clinical practice, and (4) generation of new knowledge. These four tasks are associated with the four roles that nurses take on as **knowledge workers**: **data gatherer**, **information user**, **knowledge user**, and **knowledge builder**, respectively.

Nurses are data gatherers by nature. They collect and record objective clinical data daily. These items include such things as patients' medical history, vital signs, and assessment data. As data gatherers, nurses transition to information users when they begin to interpret the data that they have collected and recorded. As information users, nurses then structure the clinical data into information that can be used to guide patient-care decisions (Snyder-Halpern et al., 2001). An example of this progression is when nurses notice that a patient's blood pressure is elevated. Information users transition to knowledge users when they notice trends in a patient's clinical data and determine whether the clinical data fall within or outside of the normal data range. Nurses transition from knowledge users to knowledge builders when they examine clinical data and trends across groups of patients. These trends are interpreted and compared to current scientific data to determine whether these data would improve the nursing knowledge domain. An example of the transition of a nurse as knowledge user to a nurse as knowledge builder is an observation of medication compliance rates over a specified time period for patients diagnosed with chronic high blood pressure, with the nurse then comparing these rates to evidence-based literature to determine whether this information improves the nursing knowledge base (Snyder-Halpern et al., 2001).

Snyder-Halpern and colleagues (2001) found that as nurses assumed each of these roles, they required different types of decision support processes to support their knowledge needs. The data gatherer requires a system that captures and stores data accurately and reliably and allows the data to be readily accessed. Most current healthcare DSSs support the nurse in this role. The

information user role requires a system that can transform clinical data into a format that allows for easy recognition of patterns and trends. These systems recognize the trend and display it for the nurse, who in turn uses this information to adjust the plan of care for the patient. The information user role is generally well supported by current DSSs. The knowledge user role is the least supported, and many systems are currently looking at ways to support nurses in this role. One advantage of these DSSs is their ability to bring knowledge to nurses so that they do not have to retrieve the information themselves, which allows them to adjust a patient's plan of care in a more efficient and timely manner. The knowledge builder role is typically seen in conjunction with the nurse–researcher and quality management roles. These roles typically look at aggregated data that have been captured over time and from numerous patients. Then these data are compared to clinical variables and interventions. This analysis then results in the development of new domain knowledge (Snyder-Halpern et al., 2001).

Most of the available DSS tools for nursing practice, although promising, are simplistic and in early development. Typically, a DSS includes tools such as (1) computerized alerts and reminders (e.g., medication due, patient has an allergy, or potassium level abnormal), (2) clinical guidelines (e.g., best practices for prevention of skin breakdown), (3) online information retrieval (e.g., CINAHL or drug information), (4) clinical order sets and protocols, and (5) online access to organizational policies and procedures. In the future, these tools may be expanded to include applications with embedded case-based reasoning.

In the context of nursing practice that is supported by CISs, nurses will eventually have access to evidence and knowledge derived from large aggregates of clinical data, including nursing interventions and resultant outcomes. Experiential evidence provides practice guidelines and directives to ensure concurrence with optimal clinical decisions and actions. To illustrate, consider this example: A nurse assesses a patient who has experienced a stroke for signs of skin breakdown, photographs and documents early skin integrity changes, and submits the photos and documentation to the CIS. The

nurse receives an option to review the best practices for care of the patient and to submit a request for a consult to a wound management specialist. The ongoing clinical findings, treatment, and response are logged and aggregated with similar cases, thereby contributing to the knowledge base related to nursing and care of the integumentary system.

The informational elements of CISs can also be designed to include specifics about individuals' multicultural practices and beliefs. Consider the situation in which a client voices concerns about her prescribed dietary treatment and expresses a preference for a female care provider. With a query to the CIS for the client's history and sociocultural background, the nurse obtains explanations for these requests that derive from the patient's religious and cultural background and makes a notation to highlight and carry this information forward in the electronic record for any future admissions. Future systems may also be designed to provide access to standards of ethical practice and online access to experts in the field of moral reasoning to guide clinical interactions and decision-making.

Through each instance of interacting with the CIS, nurses add to this repository of knowledge by chronicling their daily clinical challenges and queries. The delivery of personalized, knowledge-based care is enhanced by the continued expansion and aggregation of knowledge about clients and populations, which includes their personal, cultural, physical, and clinical presentations and experiences coupled with the guidance received from others.

Graves and Corcoran (1989) have suggested that nursing knowledge is "simultaneously the laws and relationships that exist between the elements that describe the phenomena of concern in nursing (factual knowledge) and the laws or rules that the nurse uses to combine the facts to make clinical nursing decisions" (p. 230). In their view, not only does knowledge support decision-making, but it also leads to new discoveries. Thus, one might think about the future creation of nursing knowledge as being the discovery of new laws and relationships that can continue to advance nursing practice.

New technologies have made the capture of multifaceted data and information possible using such technologies as digital imaging (e.g., photography to support wound management). Now included as part of the clinical record, such images add a new dimension to the assessment, monitoring, and treatment of illness and the maintenance of wellness. Beyond the use of computer keyboards, input devices are being integrated with CISs and used to gather data and information for the following clinical and administrative purposes:

- Biometrics (e.g., facial recognition and security)
- Voice and video recordings (e.g., client interviews and observations, diagnostic procedures, and ultrasounds)
- Voice-to-text files (e.g., voice recognition for documentation)
- Medical devices (e.g., infusion pumps, ventilators, and hemodynamic monitors)
- Barcode and radio-frequency identification (RFID) technologies (e.g., medication administration)
- Telehomecare monitoring (e.g., for use in diabetes and other chronic disease management)

These are but a few of the emerging capabilities that allow for numerous data inputs to be transposed, combined, analyzed, and displayed to provide information and views of clinical situations currently not possible with hard copy documentation. Through the application of information and communication technologies to support the capture and processing (i.e., interpreting, organizing, and structuring) of all relevant clinical data, relationships can be identified and formalized into new knowledge. This transformational process is at the core of generating new nursing knowledge at a rate never experienced before; in the context of current research paradigms, the same relationships would likely take years to uncover.

As CISs advance, nurses will eventually become generators of new knowledge by virtue of designs that embed machine learning and

case-based reasoning methods within their core functionality. This functionality will become possible only with national and international adoption of a standardized nursing language, which is described in the following section. Imagine the power of having access to systems that aggregate the same data elements and information garnered from multiple clinical situations and provide a probability estimate of the likely outcome for individuals of a certain age, with a specific diagnosis and comorbid conditions, medication profile, symptoms, and interventions. How much more rapidly would an understanding of the efficacy of clinical interventions be elucidated? Historically, some knowledge might have taken years of research to discover—for example, that sometimes long-standing practices are more harmful than beneficial. A case in point is the long-standing practice of instilling endotracheal tubes with normal saline before suctioning (O'Neal et al., 2001). Based on the evidence gathered through several studies, the potentially deleterious effects of this practice have become widely recognized. Conceivably, a meta-analysis approach to clinical studies would be expedited by convergence of large clinical data repositories across care settings, thereby making available to practitioners the collective contributions of health professionals and longitudinal outcomes for individuals, families, and populations.

Nurses need to be engaged in the design of CIS tools that support access to and the generation of nursing knowledge. As we have emphasized, the adoption of clinical data standards is of particular importance to the future design of CIS tools. We are also beginning to see the development and use of expert systems, which implement knowledge automatically without human intervention. For example, an insulin pump that senses the patient's blood glucose level and administers insulin based on those data is a form of an **expert system**. Expert systems differ from decision support tools in that the decision support tools require the human to act on the information provided, whereas expert systems intervene automatically, based on an algorithm that directs the intervention. Consider that as CISs are widely implemented, standards for nursing documentation and reporting are adopted, and healthcare IT

solutions continue to evolve, the synthesis of findings from a variety of methods and worldviews becomes much more feasible.

Central to the development of robust expert systems is the agreement on and use of standard data formats and terminologies that accurately codify and capture the essence of nursing processes and outcomes in these electronic systems. Consider that physician contributions to the health of a patient have been specifically codified (and billed) for some time (i.e., ICD-10). What if we were able to code and thus capture nursing contributions in a similar way? This information would help to highlight the specific nursing contributions to patient outcomes.

Capturing and Codifying the Work of Nursing

There are major efforts underway—internationally through the International Council of Nurses' **International Classification of Nursing Practice (ICNP)** and in many other initiatives among and within countries—in which nurses are attempting to standardize the language of nursing practice (Hannah et al., 2009). These efforts are particularly important in the face of the development of EHRs and health information exchanges (HIEs), which have been stimulated by the HITECH Act of 2009. The capacity to encourage and enforce consistent nomenclatures that reflect the practice of nurses is now possible. Standardized language gives both the nursing profession and the healthcare delivery systems the capability to capture, codify, retrieve, and analyze the impact of nursing care on client outcomes. For example, with the use and documentation of standardized client assessments, including risk measures, interventions based on best practices, and consistently measured outcomes within different care settings and across the continuum of care, there will be an ability to demonstrate more clearly the contributions and impact of nursing care through the analysis of EHR outputs. In addition, clinical outcomes can be further understood in the context of care environments, particularly implications related to the availability of human and material resources to support care delivery. The standardization of clinical inputs and outputs into EHRs will eventually provide a rich knowledge base from which practice and research can be enhanced and administrative and policy decisions can be better informed (Nagle et al., 2010). According to Androwich (2010), it is important to understand that there is a dual role for accessing and using information (content) in health care. In the first instance, when the nurse is caring for an individual patient, evidence-based information (content) and patient data need to be available at the point of care to inform the present patient encounter. In the second instance, patient data that are entered by the nurse in the process of documentation need to be entered in

such a manner that they are able to be aggregated to inform future patient encounters.

Rutherford (2008) provided this insight:

> *A standardized nursing language should be defined so that nursing care can be communicated accurately among nurses and other health care providers. Once standardized, a term can be measured and coded. Measurement of the nursing care through a standardized vocabulary by way of an ED [electronic documentation] will lead to the development of large databases. From these databases, evidence-based standards can be developed to validate the contribution of nurses to patient outcomes.* (para. 5)

Thede and Schwiran (2011) identified the benefits of using standardized terminology as (1) better communication among nurses and other healthcare providers, (2) increased visibility of nursing interventions, (3) improved patient care, (4) enhanced data collection to evaluate nursing care outcomes, (5) greater adherence to standards of care, and (6) facilitation of assessment of nursing competency (para. 2).

Think about this. Some EHRs measure height in feet and inches and others in centimeters. Weight may be measured in pounds or kilograms. If we wanted to compare patient data from multiple EHRs in several healthcare institutions to develop a model to predict the onset of type 2 diabetes, these disparate measures would not translate well. Some EHRs force data collection into coded database fields, and thus these data are more easily analyzed for trends than those same data recorded as free text. Clinicians who are used to recording data (charting) as text may resist the use of the coded data fields that are typically presented as drop-down menus in the EHR. As Skrocki (2013) pointed out, "Data interoperability is hindered when clinicians utilize free text documentation. Although text data can be searched with a specific word or word phrases, it does not allow for optimal data sharing. When an organization transfers data to another organization, standardized codified data allows for better data interpretation" (p. 77).

Although significant progress has been made in this standardization work, it is still evolving. **Box 6-1** discusses the

evolution of standardized terminologies in nursing; it was contributed by Nicholas Hardiker (2011), a leader in the development of standardized languages that support clinical applications of information and communication technology.

BOX 6-1 THE EVOLUTION OF STANDARDIZED TERMINOLOGIES TO SUPPORT NURSING PRACTICE

Nicholas Hardiker

Agreement on the consistent use of a term, such as *impaired physical mobility* allows that term to be used for a number of purposes: to provide continuity of care from care provider to care provider, to ensure care quality by facilitating comparisons between care providers, or to identify trends through data aggregation. Since the early 1970s, there has been a concerted effort to promote consistency in nursing terminology. This work continues today, driven by the following increasing demands placed on health-related information and knowledge:

- *Accessibility*: **Accessibility** means that the information and knowledge needed to deliver care or manage a health service should be easy to access.
- *Ubiquity*: **Ubiquity** means that with changing models of healthcare delivery, information and knowledge should be available anywhere.
- *Longevity*: Information should be usable beyond the immediate clinical encounter.
- *Reusability*: **Reusability** means that information should be useful for a range of purposes.

Without consistent terminology, nursing runs the risk of becoming invisible; nursing will remain difficult to quantify, the unique contribution and impact of nursing will go unrecognized, and the nursing component of EHR systems will remain rudimentary at best. Not least, without consistent terminology, the nursing knowledge base will suffer in terms of development and access, thereby delaying the integration of evidence-based health care into nursing practice.

External pressures merely compound this problem. For example, in the United States, the HITECH Act, signed in January 2009, provided a financial incentive for the use of EHRs; similar steps were taken in other regions. The HITECH Act mandated that EHRs be used in a meaningful way, but without consistent terminology, achieving this goal will be problematic. Finally, the current and future landscape of information and communication technologies (e.g., connection anywhere, borderless communication, web-based applications, collaborative working, disintermediation and reintermediation, consumerization, ubiquitous advanced digital content [van Eecke et al., 2007]) and their inevitable infiltration into health care will only serve to reinforce the need for consistent nursing terminology while providing an additional sense of urgency.

This box explains what is meant by a standardized nursing terminology and lists several examples. It describes in detail the different approaches taken in the development of two terminologies. It presents, in the form of an international technical standard, a means of ensuring consistency among the plethora of contemporary standardized nursing terminologies, with a view toward harmonization and possible convergence. Finally, it provides a rationale for the shared development of models of terminology use—models that embody both clinical and pragmatic knowledge to ensure that contemporary nursing record systems reflect the best available evidence and fit comfortably with routine practice.

STANDARDIZED NURSING TERMINOLOGIES

A term at its simplest level is a word or phrase used to describe something concrete (e.g., *leg*) or abstract (e.g., *plan*). A nursing terminology is a body of the terms used in nursing. Many nursing terminologies exist, both formal and informal. Nursing terminologies allow nurses to consistently capture, represent, access, and communicate nursing data, information, and knowledge. A **standardized nursing terminology** is a nursing terminology that is in some way approved by an appropriate authority (de jure standardization) or by general consent (de facto standardization).

In North America, one such authority was the ANA, which operated a process of de jure standardization through its Committee for Nursing Practice Information Infrastructure (CNPII), which now no longer exists. The CNPII recognized two data element sets: the Nursing Minimum Data Set (NMDS) and the Nursing Management Minimum Data Set (NMMDS). In the United States, work on a standardized data element set for nursing began in the 1980s with the NMDS (Werley & Lang, 1988), which provided an additional catalyst for the development of many nursing terminologies that could provide values (e.g., chronic pain) for particular data elements in the NMDS (e.g., nursing diagnosis). The data element sets provided a framework for the uniform

collection and management of nursing data and encouraged the use of a standardized nursing terminology to represent those data as a way to enhance consistency.

APPROACHES TO NURSING TERMINOLOGY

From relatively humble beginnings, nursing terminologies have evolved significantly over the past several decades in line with best practices in terminology work. The **enumerative approach** consists of words or phrases in a list or a simple hierarchy format. In the nursing diagnosis terminology system of the North American Nursing Diagnosis Association (NANDA), a nursing diagnosis has an associated name and a textual definition (NANDA International, 2008). Each nursing diagnosis may have a set of defining characteristics and related risk factors. These additional features do not constitute part of the core terminology but instead are intended to be used as an aid to diagnosis. What an enumerative approach to standardizing terminology may lack in terms of hierarchical sophistication, it makes up for in terms of simplicity and potential ease of implementation and use.

In contrast, the **ontological approach** is compositional in nature and provides a partial representation of the entities within a domain and the relationships between them. The evolution of this approach to terminology standardization has been facilitated by advances in knowledge representation (e.g., the refinement of the description logic that underpins many contemporary ontologies) and in their accompanying technologies (e.g., automated reasoners that can check consistency and identify equivalence) as well as the subsumption (i.e., subclass–superclass) relationships within those ontologies.

ICNP version 2 is an example of an ontology. ICNP is described as a unified nursing language system. It seeks to provide a resource that can be used to develop local terminologies and facilitate cross-mapping between terminologies to compare and combine data from different sources; the existence of a number of overlapping but inconsistent standardized nursing terminologies is problematic in terms of data comparison and aggregation. The core of ICNP is represented in the Web Ontology Language (OWL), a recommendation of the World Wide Web Consortium (W3C) and a de facto standard language for representing ontologies (McGuiness & van Harmelen, 2004). Because it is underpinned by description logic, OWL permits the use of automated reasoners that can check consistency, identify equivalence, and support classification within the ICNP ontology.

The results of contemporary terminology work are encouraging. Nevertheless, further work is needed to harmonize standardized nursing terminologies and scale up and mainstream the development and implementation of models of terminology use.

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Werley, H. H., & Lang, N. M. (Eds.). (1988). *Identification of the Nursing Minimum Data Set.* Springer.

At least two decades of work have been directed toward articulating standardized data elements that reflect nursing practice. The nursing profession has been steadily moving toward consensus on the adoption of data standards. In fact, several "consensus conferences" have been hosted in recent years by the University of Minnesota, with the goal to develop "a national action plan and harmonize existing and new efforts of multiple individuals and organizations to expedite integration of standardized nursing data within EHRs and ensure their availability in clinical data repositories for secondary use" (Westra et al., 2015, para. 3). See Chapter 14, *The Electronic Health Record and Clinical Informatics*, for more information about using standardized terminologies in the EHR.

The National Library of Medicine has been designated by the Department of Health and Human Services as the central coordinating body for clinical terminology standards. Its web page (www.nlm.nih.gov/healthit/index.html) provides several training and implementation resources as well as current information on updates to important terminologies.

The Office of the National Coordinator for Health Information Technology (ONC) has also been working diligently to develop national standards for EHR interoperability. The result of the work is the United States Core Data for Interoperability (USCDI) Version 3 released in July 2022. "The USCDI is a standardized set of health data classes and constituent data elements for nationwide, interoperable health information exchange" (ONC, 2022, para. 1).

Access the USCDI here: www.healthit.gov/isa/sites/isa/files/2022-07/USCDI-Version-3-July-2022-Final.pdf.

The ANA (2018) updated its position statement and advocated for "the use of the ANA recognized terminologies supporting nursing practice within the Electronic Health Record (EHR) and other health information technology solutions" (para. 2). A landscape analysis of standard nursing terminologies, conducted by the ONC (2017), reported that the ANA recognizes 12 standard nursing terminologies —2 minimum data sets, 2 reference terminologies, and 8 interface terminologies. These terminologies are provided in **Box 6-2**.

BOX 6-2 ANA-RECOGNIZED STANDARD NURSING TERMINOLOGIES

MINIMUM DATA SETS

- USA Nursing Minimum Data Set (USA NMDS): https://drive.google.com/file/d/1qWKs6OXUAGtlZ9MaYt6WnI1aS3rBZ5lW/view
- The NMDS national work supported the initiative to formulate or construct an international NMDS (i-NMDS): https://drive.google.com/file/d/1Am5yDn56RCEkFJfsvXLcPtw9C-_RLkpa/view
- Nursing Management Minimum Data Set (NMMDS): https://drive.google.com/file/d/1L2gnoALBebnirOWhyriEJUOuKWSffkfw/view

REFERENCE TERMINOLOGIES

- Logical Observation Identifiers Names and Codes (LOINC): https://loinc.org
- Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT): www.snomed.org

INTERFACE TERMINOLOGIES

- Clinical Care Classification (CCC) System: https://careclassification.org
- International Classification for Nursing Practice (ICNP): www.who.int/standards/classifications/other-classifications/international-

classification-for-nursing-practice

- North American Nursing Diagnosis Association International (NANDA-I): www.nanda.org
- Nursing Interventions Classification (NIC): www.nursing.uiowa.edu/cncce/nursing-interventions-classification-overview
- Nursing Outcomes Classification (NOC): www.nursing.uiowa.edu/cncce/nursing-outcomes-classification-overview
- Omaha System: www.omahasystem.org
- Perioperative Nursing Data Set (PNDS): https://abccodes.com

Consider that as clinical information systems are widely implemented, standards for nursing documentation and reporting are adopted, and healthcare IT solutions continue to evolve, the synthesis of findings from a variety of methods and worldviews becomes much more feasible. As we move toward a standard terminology to capture the work of nursing, we will also have the ability to mine electronic record data to tease out best practices and promote care improvements. It is important to note that we do not yet have an agreed-upon standardized terminology for nursing documentation in the EHR, as demonstrated by the list of eight ANA-recognized interface terminologies in Box 6-2. This fact is hampering seamless data exchanges among competing healthcare systems and opportunities for data mining and research. One interesting and highly developed terminology system for documenting nursing care in an EHR is the CCC (https://careclassification.org). An overview and examples of the use of this system are presented in **Box 6-3**.

BOX 6-3 CLINICAL CARE CLASSIFICATION SYSTEM

FRAMEWORK

The CCC was developed by Virginia Saba and colleagues to provide a standardized approach to clinical care documentation in an EHR. The CCC consists of 4 health care patterns (i.e., physiological, psychological, functional, and health behavioral); 21 care component classes (e.g., activity, behavior,

medication, nutrition, and elimination); 176 nursing diagnoses, 804 nursing interventions/actions, and 528 nursing outcomes; 3 outcome qualifiers (i.e., improved, stabilized, and deteriorated); and 4 action type qualifiers (i.e., monitor, perform, teach, or manage) (https://careclassification.org/framework).

CODING STRUCTURE

The concept codes promote information exchange and interoperability. Each code consists of five alphanumeric characters:

1st: Alpha character represents = care component = A

2nd: Two or three digits represent = nursing concepts = A02.1

- A nursing concept represents either a nursing diagnosis or a nursing intervention.

5th: Last digit represents either

- 1 of 3 outcome qualifiers (last digit), or
- 1 of 4 intervention action types (last digit) (https://careclassification.org/framework).

Examples:

- Diagnosis code A.01.4.1
- Intervention code A.01.3.1

Summary of steps used to build code:

1. Assessment: A—Activity
2. Diagnosis: 01.4 (subdiagnosis)—Fatigue
3. Outcome identification: 1—Improve
4. Planning: 03.1 (subintervention)—Ambulation therapy
5. Implementation (action type): 1—Assess
6. Evaluation (outcome): 1—Improved

The Online Code Builder tool allows you to practice with the system to appreciate its comprehensiveness. Please visit the following website to experience code building for yourself: https://careclassification.org/online-code-builder-1.

IT is not a panacea for all the challenges found in health care, but it will provide the nursing profession with an unprecedented capacity to generate and disseminate new knowledge at a rapid speed, thus supporting the knowledge work of nursing. To practice effectively in this ever-changing environment, all healthcare professionals,

regardless of specialty, will need a basic level of informatics education. Here we will focus on NI education.

Nursing Informatics Education

If we are to fully embrace the knowledge work of nursing, we must also embrace technologies that support knowledge and practice. The future of nursing science and NI is closely associated with nursing education and nursing research. Skiba (2007) suggested that technologically savvy and well-informed faculty who can demonstrate the appropriate use of technologies to enhance the delivery of nursing care are needed. Along those lines, Whitman-Price et al. (2012) conducted research among senior nursing students to determine perceptions of personal phone use to access healthcare information during clinical experiences. Their study indicated that ready access to electronic resources enhanced clinical decision-making and confidence in patient care. As early as 2007, Girard discussed cutting-edge operating room technologies, such as nanosurgery using nanorobots, smart fabrics that aid in patient assessment during surgery, biopharmacy techniques for the safe and effective delivery of anesthesia, and virtual reality training. She made an extremely provocative point about nursing education: "Educators will need to expand their knowledge and teach for the future and not the past. They must take heed that the old tried-and-true nursing education methods and curriculum that has lasted 100 years will have to change, and that change will be mandated for all areas of nursing" (p. 353). Bassendowski (2007) specifically addressed the potential for the generation of knowledge in educational endeavors as faculty apply new technologies to teaching and the focus shifts away from individual to group instruction, which promotes sharing and processing of knowledge. We are also likely to see more interprofessional education initiatives because professionals must be prepared to work together and support one another to ensure robust patient outcomes.

Several key national groups continue to promote the inclusion of informatics content in nursing education programs. These initiatives include the Vision Series by the National League for Nursing (NLN)

(2015), the Quality and Safety Education for Nurses (QSEN; n.d.-b) learning modules, and the Technology Informatics Guiding Education Reform (TIGER) initiative (Healthcare Information and Management Systems Society, n.d.). These organizations focus on the need to integrate informatics competencies into nursing curricula to prepare future nurses for the tasks of managing data, information, and knowledge; alleviating errors and promoting safety; supporting clinical judgment and decision-making; and improving the quality of patient care. Nurse educators are challenged to prepare informatics-competent nurses who can practice safely in technology-laden settings.

The TIGER (2007) initiative identified steps toward a 10-year vision and stated a key purpose: "to create a vision for the future of nursing that bridges the quality chasm with information technology, enabling nurses to use informatics in practice and education to provide safer, higher-quality patient care" (p. 4). The pillars of the TIGER vision include the following:

- *Management & Leadership*: Revolutionary leadership that drives, empowers, and executes the transformation of health care.
- *Education*: Collaborative learning communities that maximize the possibilities of technology toward knowledge development and dissemination, driving rapid deployment and implementation of best practices.
- *Communication & Collaboration*: Standardized, person-centered, technology-enabled processes to facilitate teamwork and relationships across the continuum of care.
- *Informatics Design*: Evidence-based, interoperable intelligence systems that support education and practice to foster quality care and safety.
- *Information Technology*: Smart, people-centered, affordable technologies that are universal, useable, useful, and standards based.
- *Policy*: Consistent, incentives-based initiatives (organizational and governmental) that support advocacy and coalition-building,

achieving and resourcing an ethical culture of safety.

- *Culture*: A respectful, open system that leverages technology and informatics across multiple disciplines in an environment where all stakeholders trust each other to work together toward the goal of high quality and safety. (p. 4)

The American Association of Colleges of Nursing (AACN) has embraced a competency-based model of nursing education. *The Essentials: Core Competencies for Professional Nursing Education* released in 2021 consists of 10 essential domains with each having 2 levels of subcompetencies reflecting entry-level and advanced-level education (AACN, 2021a). Domain 8 is titled Informatics and Healthcare Technologies and includes five competencies with subcompetencies specific to entry-level and advanced-level nursing education. The five competencies follow:

- Describe the various information and communication technology tools used in the care of patients, communities, and populations.
- Use information and communication technology to gather data, create information, and generate knowledge.
- Use information and communication technologies and informatics processes to deliver safe nursing care to diverse populations in a variety of settings.
- Use information and communication technology to support documentation of care and communication among providers, patients, and all system levels.
- Use information and communication technologies in accordance with ethical, legal, professional, and regulatory standards, and workplace policies in the delivery of care. (AACN, 2021b, para. 3)

You can view the specifics of the competencies and subcompetencies for this domain at www.aacnnursing.org/Essentials/Domains/Informatics-and-Healthcare-Technologies.

Quality and Safety Education for Nurses

As nursing science evolves, it is critical that patient care improve. Unfortunately, sometimes patient care is unsafe and less than adequate. Therefore, quality and safety have become paramount. The QSEN Institute project seeks to prepare future nurses who will have the knowledge, skills, and attitudes (KSAs) necessary to continually improve the quality and safety of the healthcare systems within which they work.

Prelicensure informatics KSAs are shown in **Table 6-1** (QSEN Institute, n.d.-c). Graduate-level informatics KSAs are shown in **Table 6-2** (QSEN Institute, n.d.-a).

TABLE 6-1 Prelicensure Informatics KSAs

Knowledge	Skills	Attitudes
Explain why information and technology skills are essential for safe patient care	Seek education about how information is managed in care settings before providing care Apply technology and information management tools to support safe processes of care	Appreciate the necessity for all health professionals to seek lifelong, continuous learning of information technology skills
Identify essential information that must be available in a common database to support patient care	Navigate the electronic health record Document and plan patient care in an	Value technologies that support clinical decision-making, error prevention, and care coordination Protect the confidentiality of protected health

Knowledge	Skills	Attitudes
Contrast benefits and limitations of different communication technologies and their impact on safety and quality	electronic health record Employ communication technologies to coordinate care for patients	information in electronic health records
Describe examples of how technology and information management are related to the quality and safety of patient care Recognize the time, effort, and skill required for computers, databases, and other technologies to become reliable and effective tools for patient care	Respond appropriately to clinical decision-making supports and alerts Use information management tools to monitor outcomes of care processes Use high-quality electronic sources of healthcare information	Value nurses' involvement in design, selection, implementation, and evaluation of information technologies to support patient care
Informatics definition: Use information and technology to communicate, manage knowledge, mitigate error, and support decision-making.		

Reproduced from Cronenwett, L., Sherwood, G., Barnsteiner, J., Disch, J., Johnson, J., Mitchell, P., Sullivan, D. T., & Warren, J. (2007). Quality and safety education for nurses. *Nursing Outlook*, *55*(3), 122–131. http://dx.doi.org/10.1016/j.outlook.2007.02.006. Copyright 2007, with permission from Elsevier.

TABLE 6-2 Graduate-Level Informatics KSAs

Knowledge	Skills	Attitudes
Contrast benefits and limitations of common information technology strategies used in the delivery of patient care Evaluate the strengths and weaknesses of information systems used in patient care	Participate in the selection, design, implementation, and evaluation of information systems Communicate the integral role of information technology in nurses' work Model behaviors that support implementation and appropriate use of electronic health records Assist team members to adopt information technology by piloting and evaluating proposed technologies	Value the use of information and communication technologies in patient care
Formulate essential information that must be available in a common database to support patient care in the practice specialty Evaluate benefits and limitations of different communication technologies and their impact on safety and quality	Promote access to patient care information for all professionals who provide care to patients Serve as a resource for how to document nursing care at basic and advanced levels Develop safeguards for protected health information Champion communication technologies that support clinical decision-making, error prevention, care	Appreciate the need for consensus and collaboration in developing systems to manage information for patient care Value the confidentiality and security of all patient records

Knowledge	Skills	Attitudes
	coordination, and protection of patient privacy	
Describe and critique taxonomic and terminology systems used in national efforts to enhance interoperability of information systems and knowledge management systems	Access and evaluate high-quality electronic sources of healthcare information Participate in the design of clinical decision-making supports and alerts Search, retrieve, and manage data to make decisions using information and knowledge management systems Anticipate unintended consequences of new technology	Value the importance of standardized terminologies in conducting searches for patient information Appreciate the contribution of technological alert systems Appreciate the time, effort, and skill required for computers, databases, and other technologies to become reliable and effective tools for patient care
Informatics definition: Use information and technology to communicate, manage knowledge, mitigate error, and support decision-making.		

Reproduced from Cronenwett, L., Sherwood, G., Pohl, J., Barnsteiner, J., Moore, D., Sullivan, D., Ward, D., & Warren, J. (2009). Quality and safety education for advanced nursing practice. *Nursing Outlook*, *57*(6), 338–348. http://dx.doi.org/10.1016/j.outlook.2009.07.009. Copyright 2009, with permission from Elsevier.

CASE STUDY: CASTING TO THE FUTURE

n the year 2030, enabled by technology, nursing practice has created a professional culture of reflection, critical inquiry, and interprofessional collaboration. Nurses use technology at the point of care in all clinical settings (e.g., primary, acute, community, and long-term care) to inform their clinical

I decisions and effect the best possible outcomes for their clients. Information is gathered and retrieved via human–technology biometric interfaces, including voice, visual, sensory, gustatory, and auditory interfaces, which continuously monitor physiological parameters for potentially harmful imbalances. Longitudinal records are maintained for all citizens, from their initial prenatal assessment to death; all lifelong records are aggregated into the knowledge bases of expert systems. These systems provide the basis of the artificial intelligence being embedded in emerging technologies. Smart technologies and invisible computing are ubiquitous in all sectors where care is delivered. Clients and families are empowered to review and contribute actively to their record of health and wellness. Invasive diagnostic techniques are obsolete, nanotechnology therapeutics are the norm, and robotics supplement or replace much of the traditional work of all health professions. Nurses provide expertise to citizens to help them effectively manage their health and wellness life plans and navigate access to appropriate information and services.

The basic education of all health professions will evolve over the next decade to incorporate core informatics competencies. In general, clinical care environments will be connected, and information will be integrated across disciplines to the benefit of care providers and citizens alike. The future of health care will be highly dependent on the use of CISs and CDSs to achieve the global aspiration of safe and quality care for all citizens.

The ideal is a nursing practice that has wholly integrated informatics and nursing education and that is driven using information and knowledge from a myriad of sources, creating practitioners whose way of being is grounded in informatics. Nursing research is dynamic and an enterprise in which all nurses are engaged by virtue of their use of technologies to gather and analyze findings that inform specific clinical situations. In every practice setting, the contributions of nurses to the health and well-being of citizens will be highly respected and will parallel, if not exceed, the preeminence granted physicians.

The Future

The future landscape is yet to be fully understood as technology continues to evolve with a rapidity that is rich with promise and potential peril. The previous case study helps us to imagine what future practice might entail. Nurse informaticists and nurse executives are anticipating that computing power will be capable of aggregating and transforming additional multidimensional data and information sources (e.g., historical, multisensory, experiential, and genetic sources) into CIS. With the availability of such rich repositories, further opportunities will open to enhance the education of health professionals, advance the design and application of CDSs, deliver care that is informed by the most current evidence, and engage with individuals and families in ways yet unimagined.

Summary

In this chapter, we have defined NI, reviewed the historical evolution of informatics, and explored the DIKW paradigm central to informatics. We also explored the need for and the development of standardized nursing terminologies to capture and codify the work of nursing and how NI supports the knowledge work of nursing. An overview of initiatives to integrate informatics education in both undergraduate and graduate nursing programs was also provided. This chapter advanced the view that every nurse's practice will make contributions to new nursing knowledge to support clinical judgment in dynamically interactive CIS environments. The core concepts associated with informatics will become embedded in the practice of every nurse, whether administrator, researcher, educator, or practitioner. Informatics will be prominent in the knowledge work of nurses, yet it will be a subtlety because of its eventual transparent integration with clinical care processes. Today and tomorrow, clinical care and clinical judgment will be substantially supported by the capacity and promise of technology.

Most importantly, readers need to contemplate a future that is not limited by the world of practice as it is known today. IT is not a panacea for all the challenges found in health care, but it will provide the nursing profession with an unprecedented capacity to rapidly generate and disseminate new knowledge. Realizing these possibilities necessitates that all nurses understand and leverage the informatician within and contribute to the future.

THOUGHT-PROVOKING QUESTIONS

1. How is the concept of wisdom in NI like or unlike professional nursing judgment? Can any aspect of nursing wisdom be automated?
2. How can a single agreed-upon model of terminology use (with linkages to a single terminology) help to integrate knowledge into routine clinical

practice?

3. Can you create examples of how expert systems (not decision support systems but true expert systems initiating actions without human intervention) can be used to support nursing practice?
4. How would you incorporate the data-to-wisdom continuum into a job description for nurses?
5. What are the possibilities for accelerating the generation and uptake of new nursing knowledge?

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CHAPTER 7

Nursing Informatics as a Specialty

OBJECTIVES

1. Describe the nursing informatics specialty.
2. Explore the scope and standards of nursing informatics practice.
3. Assess the evolving roles and competencies of nursing informatics practice.
4. Appreciate the future of nursing informatics in our rich, technology-laden healthcare environments.

KEY TERMS

- advocate/policy developer
- certificate
- certification
- clinical analyst/systems specialist
- consultant
- data
- decision support/outcomes manager
- educator
- entrepreneur
- informatics innovator
- informatics nurse specialist (INS)
- information
- interprofessional team
- knowledge

- knowledge worker
- medical informatics
- nursing informatics (NI)
- nursing informatics competencies
- product developer
- project manager
- researcher
- TIGER initiative

Introduction

In Chapter 6, *History and Evolution of Nursing Informatics*, you learned about the initiation of nursing informatics, how it is evolving, and the ways that all nurses use informatics in their practice. In this chapter, we will focus on **nursing informatics (NI)** as a specialty. NI is an established yet ever-evolving specialty. Those choosing NI as a career find it full of numerous and varied opportunities. Previously, most nurse informaticists entered the field by having an understanding of and enthusiasm for working with computers. Now, however, nurses have many educational opportunities available to become formally trained in the field of NI to become an **informatics nurse specialist (INS)**. We will explore the scope and standards of NI; NI roles, education, and specialization; rewards of working in the field; and organizations and professional journals supporting the INS.

Nursing Contributions to Healthcare Informatics

Nursing has been involved in the purchase, design, and implementation of information systems (ISs) since the 1970s (Saba & McCormick, 2006). One of the first health IS vendors studied how nurses managed patient care and realized that nursing activity was the core of patient activity and needed to be the foundation of the health, or clinical, IS. Nursing informaticists have been instrumental in developing, critiquing, and promoting standard nursing terminologies to be used in the health IS. Nursing is heavily involved in the design of educational materials for practicing nurses, student nurses, other healthcare workers, and patients. Computers have revolutionized the way individuals access information and educational and social networking processes.

Scope and Standards

NI is important to nursing and health care because it focuses on representing nursing **data**, **information**, and **knowledge**. As identified in the 2008 edition of *Nursing Informatics: Scope and Standards of Practice*, NI meets the following needs for health informatics (American Nurses Association [ANA], 2008; Brennan, 1994):

- Provides a nursing perspective
- Showcases nursing values and beliefs
- Provides a foundation for nurses in NI
- Produces unique knowledge
- Distinguishes groups of practitioners
- Emphasizes the interest for nursing
- Provides needed nursing language and word context

In 2008, the ANA published a scope and standards of NI practice. This publication included the INS standards of practice and the INS standards of professional performance and addressed the who, what, when, where, how, why, and functional roles of INS practice. Three overarching standards of practice were identified (ANA, 2008):

1. Incorporate theories, principles, and concepts from appropriate sciences into informatics practice.
2. Integrate ergonomics and human–computer interaction (HCI) principles into informatics solution design, development, selection, implementation, and evaluation.
3. Systematically determine the social, legal, and ethical impact of an informatics solution within nursing and health care. (p. 33)

In 2022, the third edition of the ANA's *Nursing Informatics: Scope and Standards of Practice* was released. The standards of practice

and professional performance for an INS are listed in **Box 7-1**.

BOX 7-1 INFORMATICS NURSE SPECIALIST STANDARDS OF PRACTICE AND PERFORMANCE

STANDARDS OF PROFESSIONAL PRACTICE FOR NURSING INFORMATICS

- Standard 1: Assessment
- Standard 2: Diagnosis, Problems, and Issues Identification
- Standard 3: Outcomes Identification
- Standard 4: Planning
- Standard 5: Implementation
- Standard 5A: Coordination of Activities
- Standard 5B: Health Teaching and Health Promotion
- Standard 6: Evaluation

STANDARDS OF PROFESSIONAL PERFORMANCE FOR NURSING INFORMATICS

- Standard 7: Ethics
- Standard 8: Culturally Congruent Practice
- Standard 9: Communication
- Standard 10: Collaboration
- Standard 11: Leadership
- Standard 12: Education
- Standard 13: Evidence Based Practice and Research
- Standard 14: Quality of Practice
- Standard 15: Professional Practice Evaluation
- Standard 16: Resource Utilization
- Standard 17: Environmental Health

Data from: American Nurses Association. (2022). *Nursing informatics: Scope and standards of practice* (2nd ed.). Nursesbooks.org.

The ANA (2018) also described the major functional areas of nursing informatics as follows:

- Administration, leadership, and management
- Analysis
- Compliance and integrity management
- Consultation
- Coordination, facilitation, and integration
- Development
- Education and professional development
- Policy development and advocacy
- Research and evaluation (para. 6)

As INSs assume their roles, it is evident that typical roles cover more than one functional area and that their "informatics solutions are more closely integrated with the delivery of care" (ANA, 2015, p. 36). The ANA also denoted telehealth as an integrated functional area that is a dynamic health information technology. As nursing, information, computer, and cognitive sciences continue to evolve, so will NI functions. For example, Kim (2020) pointed out the growing need for INSs to be fully aware of cybersecurity threats and prepared to act in cases of intentional tampering with patient information systems. According to the ANA (2018), "informatics nurses of all levels practice at the intersection of technology and clinical practice" (para. 7). With the rapid advancements we have already seen in the previous decade, we know that the INSs of the future will be assuming roles and working in areas that we have not yet imagined.

Nursing Informatics Roles

NI has become a viable and essential nursing specialty with the introduction of computers, technology, and the electronic health record (EHR) to health care. Many nurses entered the NI field because of their natural curiosity and dedication to being lifelong learners. Others who entered this field might have done so by accident. Perhaps they were comfortable working with computers, and their coworkers used them as a resource for computer-related questions. The introduction of the EHR has forced all clinicians to learn to use this new technology and incorporate it into their already busy days. According to Baumann et al. (2018), who conducted a systematic review and meta-analysis, nursing documentation time increased from 9% before EHR to 23% after EHR implementation. Assisting nurses to incorporate this new technology into their daily workflow is one of many challenges that the INS may tackle. Even though INSs appear to work behind the scenes, they affect the health and clinical outcomes of patients.

The INS may take on numerous roles (**Figure 7-1**). For example, one position that INSs fill quite well is the role of project manager as a result of their ability to simultaneously manage multiple complex situations. Because of the breadth of the NI field, however, many INSs find that they need to further specialize. The following list includes some typical INS positions, though it is far from comprehensive because this field changes rapidly, as does technology (ANA, 2015, 2022; Thede, 2003).

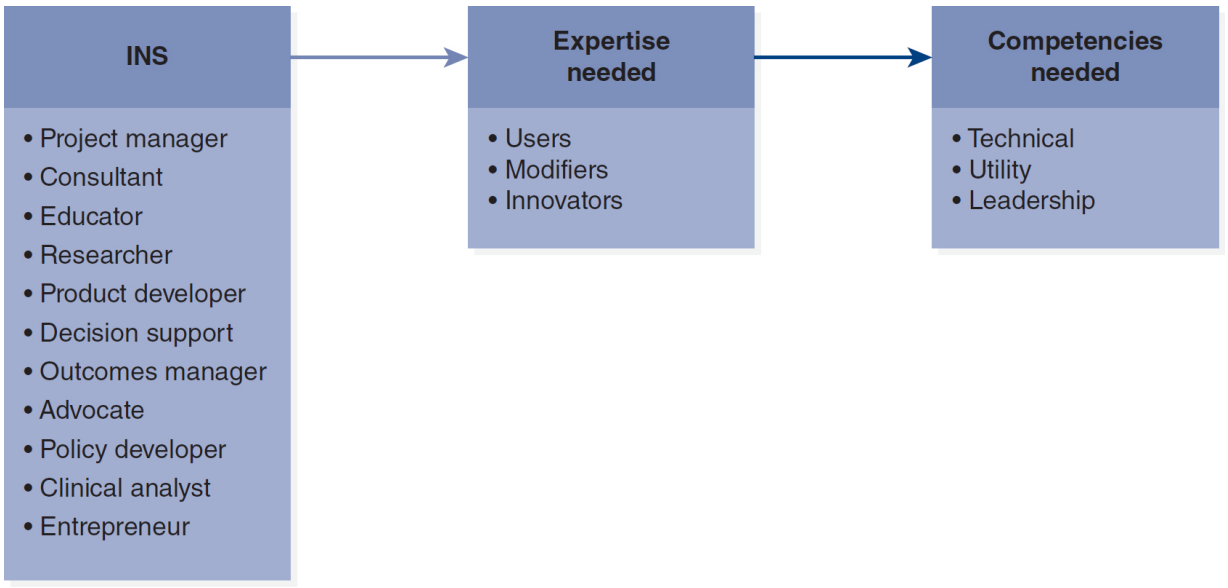


Figure 7-1 Nursing Informatics Roles

Description

- **Project manager**: In the project manager role, the INS is responsible for the planning and implementation of informatics projects. The INS uses the skills of communication, change management, process analysis, risk assessment, scope definition, and team building. This role acts as the liaison among clinicians, management, IS personnel, stakeholders, vendors, and all other interested parties.
- **Consultant**: The INS who takes on the consultant role provides expert advice, opinions, and recommendations based on their area of expertise. Flexibility, good communication skills, excellent interpersonal skills, and extensive clinical and informatics knowledge are highly desirable skill sets that the NI consultant needs.
- **Educator**: The success or failure of an informatics solution can be directly related to the education and training that are provided for end users. The INS who chooses the educator role develops and implements educational materials and sessions and provides education about the system to new or current employees during a system implementation or an upgrade.

- **Researcher**: The researcher role entails conducting research (especially data mining) to create new informatics and clinical knowledge. Research may range from basic informatics research to developing clinical decision support tools for nurses.
- **Product developer**: An INS in the product developer role participates in the design, production, and marketing of new informatics solutions. An understanding of business and nursing is essential in this role.
- **Decision support/outcomes manager**: Nurses assuming the role of decision support/outcomes manager use tools to maintain data integrity and reliability. Contributing to the development of a nursing knowledge base is an integral component of this role.
- **Advocate/policy developer**: INSs are key to advocating for the patients and healthcare systems and developing the infrastructure of health policy. Policy development on local, national, and international levels is an integral part of the advocate/policy developer role.
- **Clinical analyst/systems specialist**: INSs may work at varying levels and serve as a link between nursing and information services in healthcare organizations.
- **Entrepreneur**: The nurses involved in the entrepreneur role combine their passion, skills, and knowledge to develop marketable business ideas by analyzing nursing information needs and developing and marketing solutions.

The Nursing Informatics Working Group of the American Medical Informatics Association (AMIA; n.d.) identified the following core responsibilities for nurse informaticists to embrace:

- Concept representation and standards to support evidence-based practice, research, and education
- Data and communication standards to build an interoperable national data infrastructure

- Research methodologies to disseminate new knowledge into practice
- Information presentation and retrieval approaches to support safe patient centered care
- Information and communication technologies to address inter-professional workflow needs across all care venues
- Vision and management for the development, design, and implementation of communication and information technology
- Definition of healthcare policy to advance the public's health (para. 3)

These expanded responsibilities make clear that nurse informaticists will be instrumental in knowledge building and dissemination, promoting interoperability, supporting safe patient-centered care, ensuring interprofessional workflow and communications, and participating in key health policy decisions.

Specialty Education and Certification

Many of the original nurses who entered into NI did so without any formal education in this field. In many cases, these nurses served as the unit resource for computer or programming questions. Often, they acquired their skills through on-the-job training or by attending classes. Although this pathway to the NI field is still available today, more formal ways of acquiring these skills exist. The informatics nurse has a Bachelor of Science degree in nursing and additional knowledge and expertise in the informatics field (ANA, 2022). The INS holds an advanced degree or a post-master's certificate and is prepared to assume roles requiring this advanced knowledge. INSs may attend informatics conferences and obtain contact hours or continuing education units.

Box 7-2 lists some of the pioneering colleges and universities that offer advanced degrees or certificates in NI. This is not a comprehensive list because new programs are continually being developed. You should research local colleges and universities to see which ones have informatics programs.

BOX 7-2 FORMAL NURSING INFORMATICS EDUCATIONAL PROGRAMS

GRADUATE DEGREE PROGRAMS

- Chamberlain University: www.chamberlain.edu/admissions/graduate/Master-of-Science-in-Nursing/informatics-track
- Duke University: https://nursing.duke.edu/academic-programs/msn-master-science-nursing/health-informatics
- Excelsior University: www.excelsior.edu/program/master-of-science-in-nursing-informatics
- Loyola University Chicago: www.luc.edu/parkinson/academics/departments/healthinformaticsdatascien

ce/mshealthinformatics

- New York University: https://nursing.nyu.edu/academic-programs/masters-ms/informatics
- University of Alabama at Birmingham: www.uab.edu/nursing/home/academics/masters/msn-nursing-health-system-leadership
- University of Colorado at Denver: www.denvercollegeofnursing.edu/programs/master-of-science-in-nursing.html
- University of Iowa: https://informatics.uiowa.edu/study-opportunities/graduate-program
- University of Kansas: www.kumc.edu/health-informatics/master-in-health-informatics.html
- University of Maryland: www.nursing.umaryland.edu/academics/grad/nursing-informatics
- University of Pittsburgh: www.nursing.pitt.edu/degree-programs/master-science-nursing-msn/nursing-informatics-online
- University of Utah: https://nursing.utah.edu/programs/graduate/ms/nursing-informatics.php
- University of Washington: https://nursing.uw.edu/programs/degree/ms-cipct
- Vanderbilt University: https://nursing.vanderbilt.edu/msn/ni/index.php

CERTIFICATE PROGRAMS

- Chamberlain University: www.chamberlain.edu/academics/nursing-school/graduate-certificate-programs
- Loyola University Chicago: www.luc.edu/media/lucedu/gpem/pdfs/programsheetscurrent/HSPH-HealthInformatics.pdf
- Northeastern University: www.khoury.northeastern.edu/program/health-informatics-grad-certificate
- Penn State University: www.worldcampus.psu.edu/degrees-and-certificates/nursing-informatics-certificate/overview
- University of Iowa: https://informatics.uiowa.edu/study-opportunities/graduate-program/health-informatics/certificate-requirements

It is important to distinguish between earning a certificate in nursing informatics and earning certification. As provided in Box 7-2, there are several certificate (educational) programs in nursing and/or

health informatics. A **certificate** program "is an educational or training program that is used to teach learning objectives and assess whether those objectives were achieved by the student" (Institute for Credentialing Excellence, n.d., para. 2). In contrast, **certification** is a program "designed to test the knowledge, skills, and abilities required to perform a particular job, and, upon successfully passing a certification exam, to represent a declaration of a particular individual's professional competence" (para. 2).

Nurses who choose to specialize in informatics have several certification options available to them. The only certification specific to *nursing* informatics is offered through the American Nurses Credentialing Center, and the successful candidate is identified by the RN-BC credential. The applicant must be a licensed registered nurse with at least 2 years of recent experience and have a baccalaureate degree in nursing or a related field. The applicant must have completed 30 contact hours of continuing education in informatics within the past 3 years. The applicant must meet one of the following criteria for practice hours: (1) 2,000 hours practicing as an informatics nurse in the past 3 years, (2) 1,000 hours practicing as an informatics nurse and 12 semester hours of graduate academic credit toward an NI degree, or (3) completion of an NI degree that included at least 200 supervised practicum hours. For further information on this certification examination, visit www.nursingworld.org/our-certifications/informatics-nurse. This website includes the aforementioned criteria and provides further information about test eligibility, fees, examination content and locations, study materials, and practice tests.

The Healthcare Information and Management Systems Society (HIMSS) sponsors two certification examinations—Certified Associate in Healthcare Information and Management Systems (CAHIMS) and Certified Professional in Healthcare Information and Management Systems (CPHIMS). Candidates who successfully pass the CPHIMS examination are designated as certified professionals in healthcare information and management systems. The HIMSS examinations are open to any candidate who is involved in healthcare informatics. For CPHIMS certification, candidates must hold a position in one of the

following fields: administration/management, clinical IS, eHealth, IS, or management engineering. Candidates may include any of the following roles: chief executive officers, chief information officers, chief operating officers, senior executives, senior managers, IS technical staff, physicians, nurses, consultants, attorneys, financial advisers, technology vendors, academicians, management engineers, and students. For more information on the HIMSS certification processes, please visit www.himss.org/resources/certification.

Mack (n.d.) provided an overview of additional certifications that are available or in development in healthcare informatics: Registered Health Information Administrator (RHIA) certification, offered by the American Health Information Management Association (AHIMA) (www.ahima.org/certification-careers/certifications/rhia), and AMIA Health Informatics Certification (AHIC), through AMIA (https://amia.org/ahic).

Nursing Informatics Competencies

An ongoing challenge that has been identified in the literature and that will likely continue to plague health care is the vast differences in computer literacy and information management skills that healthcare workers possess (Gassert, 2008; McNeil et al., 2006; Topkaya & Kaya, 2015).

As early as 2001, Staggers et al. advocated that nursing students and practicing nurses should be educated on core NI competencies. Although information technology (IT) and informatics concepts certainly need to be incorporated into nursing school curricula, progress in this area has been slow. In the 1980s, a nursing group of the International Medical Informatics Association convened to develop the first level of nursing competencies. While developing these competencies, the nursing group found that nurses fell into one of the following three categories: (1) user, (2) developer, or (3) expert. These categories have since been expanded.

Staggers and colleagues (2001) decided that the NI competencies that were developed in the 1980s were inadequate and needed to be updated. These authors reviewed 35 NI competency articles and 14 job descriptions, which resulted in 1,159 items that were sorted into three broad categories: (1) computer skills, (2) informatics knowledge, and (3) informatics skills. These items were then placed in a database, where redundant items were removed. When this process was completed, 313 items remained.

When these items were then further subdivided, Staggers and colleagues (2001), along with the AMIA work group, realized that these competencies were not universal to all nurses; thus, before they could determine whether the competency was an NI competency, the nursing skill levels needed to be defined. The group determined that practicing nurses could be classified into four categories: (1) beginning nurse, (2) experienced nurse, (3) INS, and (4) **informatics innovator**. Each of these skill levels needed to be

defined before Staggers and colleagues could determine which level was the most appropriate for that skill set.

Staggers et al. (2002) conducted the seminal work in this area, a Delphi study to validate the placement of the competencies into the correct skill level. Of the 305 original competencies identified, 281 achieved an 80% approval rating for both importance as a competency and placement in the correct practice level. The authors stressed that this is a comprehensive list; thus, for a nurse to enter a particular skill level, they need not have mastered every item listed for that skill level. For a list of competencies identified by nursing skill level, see **Table 7-1**.

TABLE 7-1 Nursing Informatics Competencies by Skill Level

Based on research conducted by Hunter et al. (2013), the online TIGER-based self-assessment instrument, Assessment of Nursing Informatics Competencies (TANIC), was developed. This instrument assesses the Level 1: Beginning Nurse and Level 2: Experienced Nurse competencies.

Level 1: Beginning Nurse

- Start the computer and log on securely to access select applications/software
- Access and send email
- Collect and enter patient data into the information system

Level 2: Experienced Nurse

- Identify the risks and limitations of surfing the internet to locate evidence-based practice information
- Gather data to draw and synthesize conclusions
- Explain how to sustain the integrity of information resources

Based on the research conducted by McGonigle et al. (2015), the online self-assessment instrument, Nursing Informatics Competency Assessment—Level 3/Level 4 (NICA L3/L4), was developed. This instrument assesses the Level 3: Informatics Nurse Specialist and Level 4: Informatics Innovator competencies.

Level 3: Informatics Nurse Specialist

- Fluent in nursing informatics and nursing terminologies
- Apply aspects of human technology interface to screen, device, and software design
- Teach nurses how to locate, access, retrieve, and evaluate information

Level 4: Informatics Innovator

- Analyze systems
- Transform software programs to support data analysis and aggregation
- Lead research efforts to determine and address application needs

Hunter, K. M., McGonigle, D., & Hebda, T. (2012, June 23–27). *Operationalizing TIGER NI competencies for online assessment of perceived competency.* 11th International Congress on Nursing Informatics, Montreal, Canada, 181.

In 2004, a group of nurses came together after attending a national informatics conference to ensure that nursing was equally recognized in the national informatics movement. This so-called Technology Informatics Guiding Education Reform (TIGER) team determined that using informatics was a core competency for all healthcare workers. They also determined that many nurses lacked IT skills, which limited their ability to access evidence-based information that could otherwise be incorporated into their daily practice. This group developed a plan to include informatics courses in all levels of nursing education (HIMSS, n.d.-b). Many of the items identified by the TIGER team as lacking in both nursing students and practicing nurses are ones that Staggers et al. (2002) determined to

be NI competencies. To learn more about the **TIGER initiative**, visit www.himss.org/professionaldevelopment/tiger-initiative.

Through the work of Hunter et al. (2012, 2013, 2015) and McGonigle et al. (2013, 2015), the competencies for nursing informatics practice levels 1 through 4 have been further refined with two self-assessment tools that have been developed. Hunter and colleagues focused on the level 1 and level 2 competencies and developed the self-assessment of competencies TANIC tool, TIGER-Based Assessment of Nursing Informatics Competencies. McGonigle and colleagues focused on the competencies related to the advanced levels 3 and 4 and developed the self-assessment of competencies NICA L3/L4 tool, Nursing Informatics Competency Assessment Level 3/Level 4. "Together, these two instruments allow for comprehensive assessment of informatics competencies and hold international recognition" (ANA, 2022, p. 63).

It is critical for nurses and INSs to demonstrate competence. Because there were many definitions of the term *competency*, the authors of these tools had to first define the term. Hunter et al. (2013) concluded the following:

> *Competency, then, is a concept applicable to multiple situations. At its most basic, competency denotes having the knowledge, skills, and ability to perform or do a specific task, act, or job. Depending on the context, competency can refer to adequate or expert performance. For this research, competency was used to mean adequate knowledge, skills, and ability. Nursing-informatics competency was defined as adequate knowledge, skills, and ability to perform specific informatics tasks.* (p. 71)

The teams began instrument development by synthesizing both seminal and current literature to construct instrument items; they reviewed, formatted, and initiated instrument testing with a Delphi study and then piloted the resulting instrument with experts. Cronbach's alpha values were calculated. The TANIC Cronbach was 0.944 for clinical information management, 0.948 for computer skills, and 0.980 for information literacy. The NICA L3/L4 reliability estimates were as follows: computer skills, 0.909; informatics knowledge, 0.982; and informatics skills, 0.992. The Cronbach's

reliability estimates for each tool showed strong internal consistency reliability.

The TANIC self-assessment instrument included questions about demographics and the self-assessment, consisting of 85 items that cover basic computer literacy, clinical information management, and information literacy. The NICA L3/L4 self-assessment instrument included questions about demographics and the 178-item self-assessment, consisting of computer skills, informatics knowledge, and informatics skills.

These tools and those that will follow are extremely important because they help each of us identify our own level of comfort with technology and our self-confidence in our ability to perform these skills and tasks. Nurse educators in all practice settings and school-based programs must help their nurses or nursing students recognize deficits in their current knowledge and skills. The nurse educators can facilitate the professional development of their nurses or nursing students through the identification of courses or skill-based labs that will help them turn their deficits into strengths.

Value and Rewards of Nursing Informatics Practice

NI is a nursing specialty that does not focus on direct patient care but instead focuses on enhancing patient care and safety and improving the workflow and work processes of nurses and other healthcare workers. The INS is instrumental in designing the EHRs that healthcare workers use on a daily basis. This nurse is also responsible for designing tools that allow healthcare workers to access patient information more efficiently than they have been able to do in the past. The ANA (2022) pointed out that informatics nurses (INs) and INSs possess a "unique contextual understanding of the healthcare ecosystem" (p. 6). The INS brings value to an organization because of specialized practice expertise and a unique understanding of organizations, health policy, and research.

Change is a factor that an INS deals with daily. The dynamic nature of this position is probably its most difficult aspect because people deal with change differently. Understanding change theory and processes and appreciating how change affects people assist the INS in developing strategies to encourage healthcare workers to accept changes and become proficient in informatics solutions that have been implemented. Seeing the change adopted with a minimal amount of discord is very rewarding to the INS.

INSs also participate in informatics organizations that allow them to network and share experiences with one another. Such interactions allow them to bring new solutions back to their respective organizations and improve informatics trouble spots. Attending professional conferences allows INSs to stay abreast of changes in the industry. Continuing education may help INSs to improve a process or workflow within the hospital or to change the way a system upgrade is implemented.

Nursing Informatics Organizations and Journals

One of the first informatics organizations founded was HIMSS. Launched in 1961, HIMSS celebrated its 62nd year in 2023 and now has offices throughout the United States and Europe. HIMSS currently represents more than 120,000 individuals and 650 corporations; supports both local and national chapters; and has many associated work groups, one of which is an NI work group. HIMSS is well known for its development of industry-wide policies and its educational and professional development initiatives, all of which are directed toward the goal of ensuring safe patient care. Membership in HIMSS offers many advantages for nurses, such as access to numerous weekly and monthly publications and a scholarly journal, the *Online Journal of Nursing Informatics*. HIMSS offers several educational programs, including virtual expos, which allow participants to experience the expo without having to travel. These educational opportunities allow participants to network with colleagues and peers, which is a valuable asset in this field. HIMSS also periodically conducts NI workforce surveys. It is interesting to review the most current survey results and compare them to your setting and role.

The AMIA was founded in 1990 when three health informatics associations merged. It currently has more than 3,000 members who reside in 42 countries. Its focus is on the development and application of biomedical and healthcare informatics. Members include physicians, nurses, dentists, pharmacists, health IT professionals, and biomedical engineers. AMIA offers many benefits to its members, such as weekly and monthly publications and a scholarly journal, *JAMIA: Journal of the American Medical Informatics Association*. Members may join a working group that is specific to their specialty, including an NI working group. AMIA offers multiple opportunities for educational and networking pursuits.

The American Nursing Informatics Association (ANIA) was established in 1992 to provide an opportunity for Southern California informatics nurses to meet. It has since grown into a national organization whose members include healthcare professionals who work with clinical ISs, educational applications, data collection/research applications, and administrative/decision support systems (DSSs) as well as those who have an interest in the field of NI. In 2009, ANIA merged with the Capital Area Roundtable on Informatics in Nursing. Membership benefits include the following:

- Access to a network of more than 3,200 informatics professionals in 50 states and 30 countries
- Active email list
- Quarterly newsletter indexed in CINAHL and Thomson
- Job bank with employee-paid postings
- Reduced rate at the ANIA Annual Conference
- Reduced rate for *CIN: Computers, Informatics, Nursing*
- ANIA Online Library of on-demand and webinar education activities
- Membership in the Alliance for Nursing Informatics
- Web-based meetings
- In-person meetings and conferences held nationally and worldwide

The Alliance for Nursing Informatics (ANI) is a coalition of NI groups that represents more than 3,000 nurses and 20 distinct NI groups in the United States. Its membership represents local, national, and international NI members and groups. These individual groups have developed organizational structures and established programs and publications. ANI functions as the link between NI organizations and the general nursing and healthcare communities and serves as the united voice of NI.

Box 7-3 lists some of the organizations that have been instrumental in establishing the informatics community along with

their publications, but many other informatics groups exist.

BOX 7-3 NURSING INFORMATICS WEBSITES AND CORRESPONDING JOURNALS

- **Alliance for Nursing Informatics**
  - Website: www.allianceni.org
- **American Health Information Management Association**
  - Website: www.ahima.org
  - Journal: *Journal of AHIMA* and *Perspectives in Health Information Management* (online)
- **American Medical Informatics Association**
  - Website: www.amia.org
  - Journal: *JAMIA: Journal of the American Medical Informatics Association*
  - NI website: www.amia.org/programs/working-groups/nursing-informatics
- **American Nursing Informatics Association**
  - Website: www.ania.org (includes Capital Area Roundtable on Informatics in Nursing)
  - Journal: *Journal of Informatics Nursing*
- **Health Information and Management Systems Society**
  - Website: www.himss.org
  - Journal: *Online Journal of Nursing Informatics*: www.himss.org/resources-online-journal-nursing-informatics (Dee McGonigle and Renee Eggers cofounded this journal in 1996, making it the first online scholarly nursing journal.)
- **International Medical Informatics Association**
  - Website: https://imia-medinfo.org/wp
  - NI website: https://imia-medinfo.org/wp/sig-ni-nursing-informatics
  - Journals
    - *International Journal of Medical Informatics*: www.journals.elsevier.com/international-journal-of-medical-informatics
    - *Applied Clinical Informatics*: https://shop.thieme.com/ACI-Applied-Clinical-Informatics/1869-0327
    - *Informatics for Health and Social Care*: www.tandfonline.com/toc/imif20/current

- *Methods of Information in Medicine*: https://shop.thieme.com/Methods-of-Information-in-Medicine/0026-1270

The Future of Nursing Informatics

NI is still in its infancy, as is the technology that the INS uses on a daily basis. NI will continue to influence the development of interoperable EHRs to accurately capture and share patient data and capture the care that nurses give to patients. These are formidable challenges because much of the care provided by nurses is intangible in nature and we are still struggling with EHRs that can seamlessly share health information. In the future, the EHR will provide data to the INS that can be analyzed and then used to improve nursing workflow and determine whether current practices are the most efficient and beneficial to the patient. The HIMSS 2017 Nursing Informatics Workforce Survey reported that the most frequent job responsibilities of the INS are systems implementation, systems optimization/utilization, systems development, clinical analytics, quality initiatives and reporting, informatics education, liaison/communicator, and regulatory initiatives. The HIMSS 2020 Nursing Informatics Workforce Survey reported that the job responsibilities had remained consistent with those identified in the 2017 survey; however, project management and change control/management surfaced as new responsibilities. Nursing and health care are on a roller-coaster ride that will undoubtedly prove very interesting. New technology is being introduced at a breakneck speed, and nursing and health care must be ready to ride this roller coaster. Programs need to be developed to keep nurses and healthcare workers abreast of the technological changes as they occur, and educating new and current nurses presents a significant challenge to the INS. Therefore, the INS's future looks very promising and rewarding, and demand for INSs is only expected to grow.

As the future becomes yesterday, people are waking up to the fact that we need the entire healthcare team prepared with informatics competencies. All healthcare providers should receive education on informatics because they need basic informatics skills, such as the

ability to use search engines to find information about a specific topic. Consequently, all healthcare providers must attend classes to improve their computer skills and knowledge, and those entering the nursing field need a general knowledge of computer capabilities. Many new trends—such as Web 2.0, increased attention to evidence-based practice, and a better understanding of genomics—will affect care delivery in the 21st century, and NI nurses must be prepared to lead these efforts to improve care and help nurses have a voice in the informatics skills they need and the advances and tools they use, including the EHR (Bakken et al., 2008; Lavin et al., 2015).

INSs are also in a unique position to lead interprofessional team collaboration efforts. An **interprofessional team** is a collection of professionals (e.g., physicians, nurses, pharmacists, physical therapists, and nutritionists) who work together to deliver patient care and improve outcomes. Although the EHR is the primary documentation tool for professionals, sometimes it is difficult to surface important care information and viewpoints of other professionals because finding the documentation of other professionals may not be intuitive. INSs educated in a collaborative practice philosophy understand how to reach across professional boundaries and surface and support the unique contributions of professionals to patient care. As Christopherson et al. (2015) pointed out, "Integrated competency is essential for eliminating information silos, duplication and redundancy. Effective utilization of and implementation of technology is dependent on clinical tools that are intentionally designed to support and enhance the scopes of practice of the interprofessional team members" (p. 12). The INS is uniquely positioned to ensure that the IT tools are used effectively. Similarly, Holden et al. (2018) advocated for the involvement of informatics professionals in interprofessional team collaboration efforts. They identified seven best practices for informaticians to support interprofessional collaboration:

1. Adopt the characteristics of effective teams.
2. Practice leadership and followership.
3. Clearly communicate with the aid of tools.

4. Design team meetings for effectiveness and efficiency.
5. Articulate your skills with respect to health informatics.
6. Develop skills and knowledge in interprofessional teamwork and domains.
7. Ensure health informatics education supports interprofessional collaboration. (p. 143)

Change plays a significant part in health care today, and those interested in NI must embrace change. They must also be good at enticing others to embrace change if they want to truly transform healthcare practices and ensure excellent outcomes. Nevertheless, NI candidates must realize that change is often accompanied by resistance. For their part, INSs must be ready to leave the bedside because nurses entering into this field will no longer be giving hands-on care. NI is a very challenging but rewarding field. In an ideal world, all healthcare agencies would employ at least one INS, and all nurses would embrace the **knowledge worker** title.

We would be remiss if we did not acknowledge NI and health technology initiatives worldwide. We tend to be ethnocentric in our belief that the United States is the only leader in informatics when in fact there are strong informatics initiatives in many other countries. Cummins et al. (2016) identified nursing informatics societies in eight other countries: Australia, Canada, England, Ireland, Korea, New Zealand, Singapore, and Taiwan. In 2020, the 15th International Congress on Nursing Informatics was held in Brisbane, Australia. Previous international conferences were held in Mexico (2018), Switzerland (2016), Taiwan (2013), Canada (2012), Finland (2009), and Korea (2006). The HIMSS (n.d.-a) indicates that there are 58 chapters in the United States, Canada, and India.

In 2014, the Centers for Disease Control and Prevention (CDC; n.d.) launched a Global Health Security Agenda (GHSA) with the goal of quickly identifying and containing public health threats. We will learn more about CDC initiatives in Chapter 17, *Using Informatics to Promote Community and Population Health*. It is clear that the reach

of informatics and health technology is worldwide and ever expanding.

Summary

According to the ANA (2022), "NI is the specialty that transforms data into needed information and leverages technologies to improve health and health care equity, safety, quality, and outcomes" (p. 6). Here is our expanded definition of NI: the synthesis of nursing science, information science, computer science, and cognitive science for the purpose of managing, disseminating, and enhancing healthcare data, information, knowledge, and wisdom to improve collaboration and decision-making; provide high-quality patient care; and advance the profession of nursing. Informatics practices support nurses as they seek to care for their patients effectively and safely by making the information that they need more readily available. Nurses have been actively involved in this field since computers were introduced to health care. With the advent of the EHR, it became apparent that nursing needed to develop its own terminology related to the new technology and its applications; NI has been instrumental in this process.

Today, the healthcare industry employs the largest number of knowledge workers in the world. Nurses, as knowledge workers in technology-laden healthcare facilities, must continually improve their informatics competencies. The INS is instrumental in leading the advancement of informatics concepts and tools in all settings and across all specialties. NI is a specialty governed by standards that have been established by the ANA. Because NI is a very diverse field, many INSs eventually specialize in one segment of the field. Although NI is an established specialty, all nurses utilize the core NI principles. **Nursing informatics competencies** have been developed to encompass all levels of practice and ensure that entry-level nurses are ready to enter the more technologically advanced field of nursing as well as establishing advanced competencies for the INS's specialty practice. These competencies may be used to determine the educational needs of current staff members.

The growth of the NI field has resulted in the formation of numerous NI organizations or nursing subgroups of the **medical informatics** organizations. Nurses no longer have to enter the field by chance but instead can obtain an advanced degree in NI at many well-established universities. In addition, INSs may continue their learning by attending the numerous conferences offered.

NI has grown tremendously as a specialty since its inception and is expected to continue to grow. The NI specialty not only engages nurses and patients but also engages data to improve patient outcomes, enhance patient care, and advance the science of nursing. It will be interesting to see where NI and INSs take health care in the future.

THOUGHT-PROVOKING QUESTIONS

1. A hospital is seeking to update its EHRs. It has been suggested that an INS be hired. This position does not involve direct patient care, and the administration is struggling with how to justify the position. How can this position be justified?
2. It is important that all nurses be informatics competent at all levels. In particular, at which levels should the INS be able to exhibit competency? Provide several examples of the knowledge and skills that an INS might demonstrate.
3. How does nursing move from measuring the tasks completed to measuring the final outcome of the patient? How can the INS help us reach this goal?

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CHAPTER 8

Legislative Aspects of Nursing Informatics: HIPAA, HITECH, and Beyond

OBJECTIVES

1. Explore the Health Insurance Portability and Accountability Act (HIPAA) of 1996.
2. Describe the purposes of the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009.
3. Appreciate how the HITECH Act enhanced the security and privacy protections of HIPAA and how these protections continue to evolve as health information technology develops.
4. Survey the provisions of the 21st Century Cures Act and its impact on health.

KEY TERMS

- access
- Agency for Healthcare Research and Quality (AHRQ)
- American Recovery and Reinvestment Act (ARRA)
- certified EHR technology
- civil monetary penalty (CMP)
- compliance
- confidentiality
- consequence

- covered entity
- electronic health record (EHR)
- enterprise integration
- health disparity
- health information technology
- Health Information Technology for Economic and Clinical Health (HITECH) Act
- Health Insurance Portability and Accountability Act (HIPAA)
- healthcare-associated infection (HAI)
- meaningful use
- nursing informatics (NI)
- Office for Civil Rights (OCR)
- Office of the National Coordinator for Health Information Technology (ONC)
- patient-centered care
- policy
- privacy
- protected health information (PHI)
- qualified electronic health record
- right
- security
- standard
- treatment/payment/operations (TPO)

Introduction

Two key pieces of legislation were instrumental in shaping the **health information technology** and **nursing informatics (NI)** landscape: the **Health Insurance Portability and Accountability Act (HIPAA)** of 1996 and the **Health Information Technology for Economic and Clinical Health (HITECH) Act** of 2009. Other legislation, policies, and regulations continue to further the vision initiated by these seminal laws. This chapter presents an overview of the HITECH Act, including the Medicare and Medicaid health information technology (health IT) provisions of the law. Nurses need to be familiar with the goals and purposes of this law and how it enhances the **security** and **privacy** protections of HIPAA and appreciate how it otherwise affects nursing practice in the ever-evolving electronic health records age. Key concepts related to legislating health IT are explored in this chapter as well as newer legislation regulating medical devices and apps that support patient centeredness and the movement toward payment based on quality. **Figure 8-1** provides a snapshot of the legislation affecting the informatics landscape.

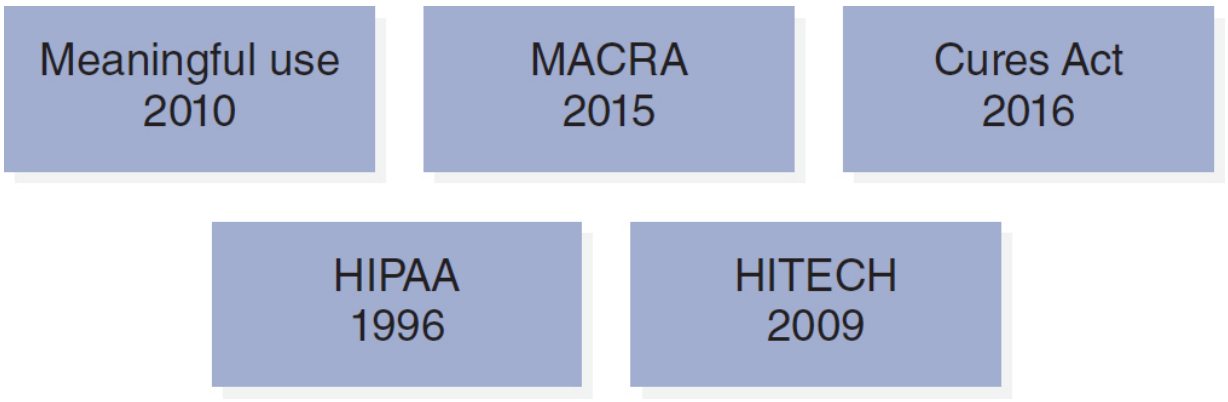


Figure 8-1 Health Informatics Regulations

HIPAA Came First

HIPAA was signed into law by President Bill Clinton in 1996. Hellerstein (1999) summarized the intent of the act as follows: to curtail healthcare fraud and abuse, enforce **standards** for health information, guarantee the security and privacy of health information, and ensure health insurance portability for employed persons. **Consequences** were put into place for institutions and individuals who violate the requirements of this act. For this text, we concentrate on the health information security and privacy aspects of HIPAA, which are outlined as follows:

> *The Health Insurance Portability and Accountability Act of 1996 (HIPAA) Rules contain privacy, security, and breach notification requirements that apply to individually identifiable health information created, received, maintained, or transmitted by health care providers who engage in certain electronic transactions, health transactions, health plans, health care clearinghouses, and their business associates. The Office for Civil Rights (OCR) is the Departmental component responsible for implementing and enforcing the privacy regulation.* (U.S. Department of Health and Human Services [HHS], 2022, para. 6–7)

The need and means to guarantee the security and privacy of health information were the focus of numerous debates. Comprehensive standards for the implementation of this portion of the act eventually were finalized, but the process to adopt final standards took years. In August 1998, HHS released a set of proposed rules addressing health information management. Proposed rules specific to health information privacy and security were released in November 1999. The purpose of the proposed rules was to balance patients' **rights** to privacy and providers' needs for **access** to information (Hellerstein, 2000).

Hellerstein (2000) summarized the proposed privacy rules as follows:

- Define **protected health information (PHI)** as "information relating to one's physical or mental health, the provision of one's health care, or the payment for that health care, that has been maintained or transmitted electronically and that can be reasonably identified with the individual it applies to" (p. 2). **Figure 8-2** depicts the types of information protected under HIPAA.

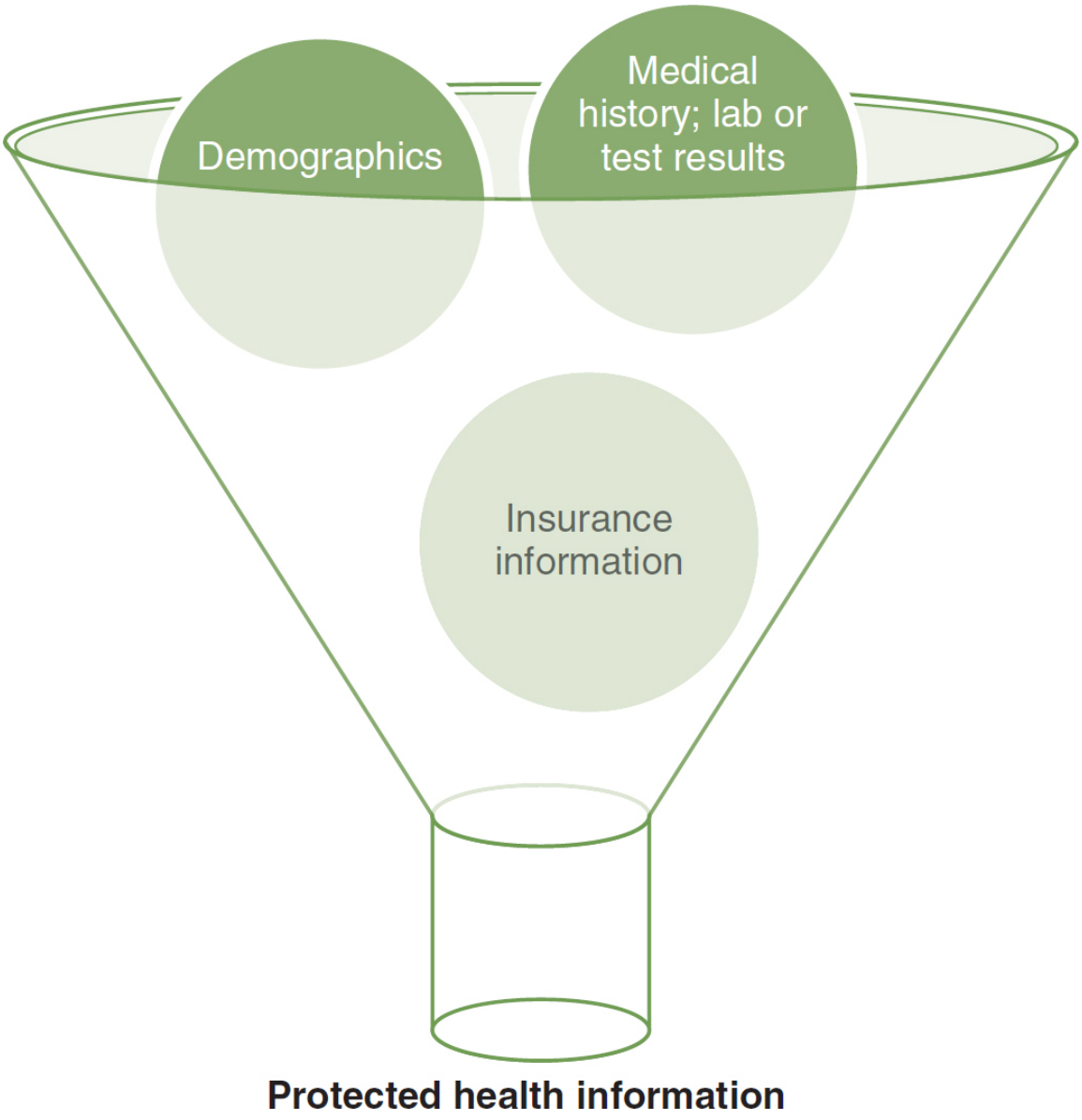


Figure 8-2 What Is Protected Health Information?

- Propose that authorization by patients for release of information is not necessary when the release of information is directly related to treatment and payment for treatment. Specific patient authorization is not required for research, medical or police emergencies, legal proceedings, and collection of data for public health concerns. All other releases of health information require a form for each release that specifies which information pertinent to the issue at hand is to be released. All releases of information must be formally documented and accessible to the patient on request.
- Establish patient ownership of the healthcare record and allow for patient-initiated corrections and amendments.
- Mandate administrative requirements for the protection of healthcare information. All healthcare organizations are required to have a privacy official and an office to receive privacy violation complaints. A specific training program for employees that includes a certification of completion and a signed statement by all employees that they will uphold privacy procedures must be developed and implemented. Every 3 years, all employees must re-sign the agreement to uphold privacy. Sanctions for violations of **policy** must be clearly defined and applied.
- Mandate that all outside entities that conduct business with healthcare organizations (e.g., attorneys, consultants, and auditors) must meet the same standards as those of the organization for information protection and security.
- Allow PHI to be released without authorization for research studies. Patients may not access their information in blinded research studies because their access may affect the reliability of the study outcomes.
- Propose that PHI may be de-identified before release in such a manner that the identity of the patient is protected. The healthcare organization may code the de-identification so that the information can be re-identified once it has been returned.

- Applies only to health information maintained or transmitted by electronic means.

As concerns mounted and deadlines loomed, the healthcare arena prepared to comply with the requirements of the law. The administrative simplification portion of this law was intended to decrease the financial and administrative burdens by standardizing the electronic transmission of certain administrative and financial transactions. This section also addressed the security and privacy of healthcare data and information for the covered entities of healthcare providers that transmit any health information in electronic form in connection with a covered transaction, health plans, and healthcare clearinghouses (Centers for Medicare and Medicaid Services [CMS], n.d.-a).

The privacy requirements, which went into effect on April 14, 2003, limited the release of PHI without the patient's knowledge and consent. Covered entities must comply with the requirements. Notably, they must dedicate a privacy officer, adopt and implement privacy procedures, educate their personnel, and secure their electronic patient records. Most individuals are familiar with the need to notify patients of their privacy rights because of their having had to sign forms before interacting with their own healthcare providers.

The Privacy Rule provided certain rights to patients: the right to request restrictions to access of the health record, the right to request an alternative method of communication with a provider, the right to receive a paper copy of the notice of privacy practices, the right to file a complaint if the patient believes their privacy rights were violated, the right to inspect and copy one's health record, the right to request an amendment to the health record, and the right to see an account of disclosures of one's health record. These rights placed the burden of maintaining privacy and accuracy on the healthcare system rather than on the patient.

On October 16, 2003, the standards for electronic transactions and code sets became effective. At that time, the standards did not require electronic transmission but rather mandated that if transactions were conducted electronically, they must comply with

the required federal standards for electronically filed healthcare claims. "The Secretary has made the Centers for Medicare & Medicaid Services (CMS) responsible for enforcing the electronic transactions and code sets provisions of the law" (Indian Health Service, 2003, para. 3).

The security requirements went into effect on April 21, 2005, and required the covered entities to put safeguards into place that protect the **confidentiality**, integrity, and availability of PHI when stored and transmitted electronically.

The safeguards that were addressed were administrative, physical, and technical. The administrative safeguards refer to the documented formal policies and procedures that are used to manage and execute the security measures. They govern the protection of healthcare data and information and the conduct of the personnel. The physical safeguards refer to the policies and procedures that must be in place to limit physical access to electronic information systems. Technical safeguards are the policies and procedures used to control access to healthcare data and information. Safeguards need to be in place to control access, whether the data and information are at rest; residing on a machine or storage medium; being processed; or in transmission, such as being backed up to storage or disseminated across a network.

Overview of the HITECH Act

The federal HITECH Act, enacted February 17, 2009, is part of the **American Recovery and Reinvestment Act (ARRA)**. The ARRA, also known as the Stimulus law, was enacted to stimulate various sectors of the U.S. economy during the most severe recession this country had experienced since the Great Depression of the late 1920s and early 1930s. The health IT industry was one area where lawmakers saw an opportunity to stimulate the economy and improve the delivery of health care at the same time. This explains why the title of the HITECH Act contains the phrase "for Economic and Clinical Health."

The ARRA is a lengthy piece of legislation that is organized into two divisions, A and B. Each division contains several titles. Title XIII of Division A of the ARRA is the HITECH Act. It addresses the development, adoption, and implementation of health IT policies and standards and provides enhanced privacy and security protections for patient information—an area of the law that is of paramount concern in NI. Title IV of Division B of the ARRA is considered part of the HITECH Act. It addressed Medicare and Medicaid health IT and provided significant financial incentives to healthcare professionals and hospitals that adopted and engaged in the "meaningful use" of **electronic health record (EHR)** technology.

At the time the HITECH Act was enacted, it was estimated that fewer than 8% of U.S. hospitals used a basic EHR system in at least one of their clinical units and that fewer than 2% of U.S. hospitals had an EHR system in all of their clinical settings (Ashish et al., 2009). Not surprisingly, the cost of an EHR system was a major barrier to widespread adoption of this technology in most healthcare facilities. The HITECH Act sought to change that situation by providing each person in the United States with an EHR. In addition, a nationwide health IT infrastructure would be developed so that access to a person's EHR would be readily available to every healthcare provider who treats the patient, no matter where the

patient may be located at the time treatment is rendered. According to the **Office of the National Coordinator for Health Information Technology (ONC)**, 96% of hospitals and 78% of physician's offices have EHR technology certified by HHS (ONC, n.d.-c).

Definitions

The HITECH Act included some important definitions that anyone involved in NI should know:

- **Certified EHR technology**: The term *certified EHR technology* means that an EHR meets specific governmental standards for the type of record involved, whether it be an ambulatory EHR used by office-based healthcare practitioners or an inpatient EHR used by hospitals. The specific standards that are to be met for any such EHRs are set forth in federal regulations.
- **Enterprise integration**: The term *enterprise integration* means the electronic linkage of healthcare providers, health plans, the government, and other interested parties to enable the electronic exchange and use of health information among all the components in the healthcare infrastructure.
- Healthcare provider: The term *healthcare provider* includes hospitals, skilled nursing facilities, nursing homes, long-term care facilities, home health agencies, hemodialysis centers, clinics, community mental health centers, ambulatory surgery centers, group practices, pharmacies and pharmacists, laboratories, physicians, and therapists.
- Health information technology: The term *health information technology* means "hardware, software, integrated technologies or related licenses, intellectual property, upgrades, or packaged solutions sold as services that are designed for or support the use by healthcare entities or patients for the electronic creation, maintenance, access, or exchange of health information."

- **Qualified electronic health record**: The term *qualified electronic health record* means "an electronic record of health-related information on an individual." A "qualified" EHR contains a patient's demographic and clinical health information, including the medical history and a list of health problems, and is capable of providing support for clinical decisions and entry of physician orders. It must also have the capacity "to capture and query information relevant to health care quality" and "exchange electronic health information with, and integrate such information from other sources." (ONC, 2009, pp. 8–9)

Purposes

The HITECH Act established the ONC within HHS. The ONC, headed by the national coordinator, was charged with overseeing the development of a nationwide health IT infrastructure that supported the use and exchange of information to achieve the following goals:

1. Improve healthcare quality by enhancing coordination of services between and among the various healthcare providers a patient may have, fostering more appropriate healthcare decisions at the time and place of delivery of services, and preventing medical errors and advancing the delivery of **patient-centered care**
2. Reduce the cost of health care by addressing inefficiencies, such as duplication of services within the healthcare delivery system, and reducing the number of medical errors
3. Improve people's health by promoting prevention, early detection, and management of chronic diseases
4. Protect public health by fostering early detection and rapid response to infectious diseases, bioterrorism, and other situations that could have a widespread impact on the health status of many individuals
5. Facilitate clinical research
6. Reduce **health disparities**

7. Better secure patient health information

The responsibilities of the ONC have evolved over time, although the core responsibilities of supporting the adoption of health IT and promoting health information exchange remain unchanged. The ONC's current strategic goals follow:

- Advance person-centered and self-managed health
- Transform health care delivery and community health
- Foster research, scientific knowledge, and innovation
- Enhance the nation's health IT infrastructure (ONC, n.d.-a)

Improving healthcare quality has been an ongoing challenge in the United States. According to the **Agency for Healthcare Research and Quality (AHRQ)**, quality health care is "described in terms of six priorities: patient safety, person-centered care, care coordination, effective treatment, healthy living, and care affordability" (AHRQ, 2022, para 1). AHRQ, an agency within HHS, has been releasing a *National Healthcare Quality and Disparities Report* every year since 2003. Access the 2022 report at www.ahrq.gov/research/findings/nhqrdr/nhqdr22/index.html.

The prevalence of **healthcare-associated infections (HAIs)** serves as an excellent example of how the use of EHR technology and a nationwide health IT infrastructure played a significant role in addressing healthcare quality issues. The *National Healthcare Quality and Disparities Report* suggested that "[w]ound infection following surgery is a common HAI. Hospitals can reduce the risk of surgical site infection by making sure patients get the right antibiotics at the right time on the day of their surgery. Surgery patients who get antibiotics within the hour before their operation are less likely to get wound infections than those who do not" (AHRQ, 2009, p. 110). Crader and Varacallo (2020) verified that this is an ongoing and accepted practice. The evolving U.S. health IT infrastructure has enabled us to track this issue for all surgical patients and thus develop evidence-based care plans to ensure that all patients within the infrastructure receive the same quality of care. This is just one of

many examples in which the end result of EHR adoption is better patient outcomes.

EHR technology makes it easier for all providers involved in a patient's care to readily access that patient's complete and current healthcare record, thereby allowing providers to make well-informed, efficient, and effective decisions about a patient's care at the time those decisions need to be made. Being able to do this is of tremendous benefit to the patient and promotes a higher level of patient-centered care. It also allows effective coordination of care between and among all providers involved in the patient's care, including doctors, nurses, therapists, nutritionists, hospitals, nursing homes, rehabilitation facilities, home health agencies, laboratories, and other diagnostic centers, thereby assuring the continuum of patient care.

Such an integrated system has clear benefits for patients and providers alike. For example, imagine how much easier it would be for a patient with a rare form of cancer to obtain a second oncologist's opinion before beginning a course of treatment. The patient's complete record, including the results of numerous diagnostic tests conducted at multiple sites, such as blood tests, biopsies, radiographs, and scans, would be readily available to the second oncologist. Imagine how much easier it would be for a patient with end-stage renal disease, who is receiving outpatient hemodialysis several times a week, to receive appropriate treatment if they were suddenly hospitalized or would like to take a vacation out of state. Imagine how much easier it would be for nurses to complete a medication reconciliation for a newly admitted patient. The possibilities are endless, and the savings realized from enhancing quality, avoiding duplication of services, and streamlining delivery of patient care are obvious.

Reducing healthcare errors is another ongoing challenge in the United States. Healthcare providers strive to meet the standard of care and avoid harm to patients. Patients have a right to receive appropriate care, but that does not always happen. The seminal report, *To Err Is Human: Building a Safer Health System*, issued by the Institute of Medicine's Committee on the Quality of Health Care

in America, undertook a comprehensive literature review and summarized the results of more than 40 studies about healthcare errors (Institute of Medicine, 2000). That report concluded that approximately 44,000 to 98,000 people in the United States die each year as a result of healthcare errors. Many thousands more who do not die are seriously injured from such errors. In addition to the human pain and suffering associated with healthcare errors, the monetary costs of these errors are substantial. Although progress in reducing healthcare errors has been made since the release of *To Err Is Human*, substantial work remains to be done. It is anticipated that a nationwide health IT infrastructure will contribute to a reduction in healthcare errors by providing mechanisms to assist with the prevention of errors and to provide timely warnings of the possibility of a repetitive error that may affect many patients.

Containing and reducing healthcare costs in the United States, where more than $4.3 trillion is spent on health care each year with a projected increase by 2028 of $6.2 trillion, is another daunting challenge (CMS, n.d.-c). Using EHR technology and a nationwide health IT infrastructure to improve quality and reduce errors within the healthcare delivery system is one way to address this challenge.

Promoting prevention, early detection, and management of chronic diseases was another purpose of the HITECH Act. The delivery of health care in the United States traditionally has been based on a disease model rather than on a wellness model. Having an EHR for everyone helps with the necessary transition as providers and their patients become more aware of the variables that positively or negatively affect health. The ability to collect and analyze data to identify appropriate choices to promote wellness and either prevent illness and injury or detect and manage chronic diseases sooner is well supported by the EHR.

Chronic diseases are of major concern to this country not only because of the impact they have on individuals but also because of the tremendous cost associated with providing treatment for patients with these conditions. Adult-onset diabetes, for example, has reached epidemic proportions. A national health IT infrastructure helps providers better identify those patients who are at risk for

developing this disease and provide treatment strategies to avoid it. Providers of those patients who develop type 2 diabetes can predict and diagnose the condition much sooner and manage it more effectively because of the vast resources provided by the national health IT infrastructure.

Improving public health was another purpose of the HITECH Act. The recent pandemic challenge is illustrative of how a national health IT infrastructure can protect public health by fostering early detection and rapid response to infectious diseases, bioterrorism, and other situations that could have a widespread effect on the health status of many individuals and groups.

The effect that a national health IT infrastructure has and will continue to have on clinical research is self-evident. As the infrastructure evolves, the amount of data that is readily available for clinical research will increase exponentially. The ability of researchers to conduct studies and provide clinicians with the most current evidence-based practice is of tremendous benefit to patients everywhere.

Reducing health disparities was another purpose of the HITECH Act. Disparities are differences in access to and quality of care in subpopulations. Detailed information about healthcare disparities can be found at the website for the Office of Health Equity at www.cdc.gov/minorityhealth. The AHRQ routinely examines the issue of disparities in health care and reports its findings to the public. Access the report at www.ahrq.gov/research/findings/nhqrdr/index.html.

All patients, regardless of race, ethnicity, or socioeconomic status, should receive care that is effective, safe, equitable, and timely. When the national health IT infrastructure contemplated by the HITECH Act is fully implemented, such disparities are bound to decrease. The ability to monitor for disparities and promote the delivery of appropriate care to all patients will be enhanced. Clinicians will be prompted to base their treatments on appropriate factors and avoid biased care.

Perhaps the most important task that faced the national coordinator during the development and implementation of a

nationwide health IT infrastructure was ensuring the security of the PHI within that system. The ability to secure and protect confidential patient information has always been of paramount importance to clinicians, who view this consideration as an ethical and legal obligation of practice. Patients value their privacy, and they have a right to expect that their confidential health information will be properly safeguarded. Nurses have been complying with the regulatory requirements of HIPAA for years, and the HITECH Act enhanced the security and privacy protections each patient has a right to expect under HIPAA. The specific changes are discussed in greater detail later in this chapter.

How a National Health IT Infrastructure Was Developed

Developing a national health IT infrastructure is an enormous and extremely complex undertaking that requires extensive financial, technological, and human resources. The HITECH Act established the ONC, as noted earlier, and HHS appointed a national coordinator who is responsible for the development of the infrastructure. The HITECH Act also established two committees within the ONC: the Health IT Policy Committee and the Health IT Standards Committee.

The Policy Committee was responsible for making recommendations to the coordinator about how to implement the requirements of the HITECH Act, such as the technologies to use in the infrastructure. The Standards Committee was responsible for recommending standards by which health information was to be electronically exchanged. These two committees have since been replaced by the Health Information Technology Advisory Committee (HITAC), established by the 21st Century Cures Act (discussed later). HITAC is charged with recommending "policies, standards, implementation specifications, and certification criteria, relating to the implementation of a health information technology infrastructure, nationally and locally, that advances the electronic access, exchange, and use of health information" (ONC, n.d.-b, para. 1).

The national coordinator is charged with providing overall leadership and strategic direction for the ONC, and these duties will continue to evolve as the health IT infrastructure evolves. The Federal Register has indicated that the national coordinator of the ONC

1. ensures the interoperability of health information, as central and foundational to the core mission of HHS to enhance and protect the health and well-being of all Americans;

2. ensures that health information technology initiatives are coordinated across HHS programs;
3. ensures that health information technology policy and programs of HHS are coordinated with those of relevant executive branch agencies (including Federal commissions and advisory committees) with a goal of avoiding duplication of effort and of helping to ensure that each agency undertakes activities primarily within the areas of its greatest expertise and technical capability;
4. reviews Federal health information technology investments to ensure Federal health information programs are meeting the objectives of the strategic plan required under Executive Order 13335, to create a national interoperable health information technology infrastructure;
5. provides comments and advice regarding specific Federal health information technology programs; and
6. develops, maintains, and reports on measurable outcome goals for health information technology to assess progress within HHS and other executive branch agencies (HHS, 2018)

The HITECH Act also provided significant monetary incentives for providers who engaged in meaningful use of health IT. **Meaningful use** was defined as "electronically capturing health information in a coded format, using that information to track key clinical conditions, communicating that information to help coordinate care, and initiating the reporting of clinical quality measures and public health information" (CMS, 2010, para. 6). Monetary incentives were available to clinicians and facilities that implemented EHR systems that met the specific standards. The term *meaningful use* has since been replaced by provisions outlined in the Medicare Access and CHIP Reauthorization Act (MACRA) of 2015.

How the HITECH Act Changed HIPAA

HIPAA Privacy and Security Rules

Nurses have been complying with HIPAA for years. HIPAA was enacted by the federal government for several purposes, including better portability of health insurance as a worker moved from one job to another; deterrence of fraud, abuse, and waste within the healthcare delivery system; and simplification of the administrative functions associated with the delivery of health care, such as reimbursement claims sent to Medicare and Medicaid. Simplification of administrative functions entailed the adoption of electronic transactions that included sensitive healthcare information. To protect the privacy and security of health information, two sets of federal regulations were implemented: The Privacy Rule became effective in 2003, and the Security Rule became effective in 2005. Many practitioners who refer to HIPAA are not referring to the comprehensive federal statute enacted in 1996 but rather to the Privacy Rule and the Security Rule, the federal regulations that were adopted years after HIPAA became law.

Under the Privacy Rule, patients have a right to expect privacy protections that limit the use and disclosure of their health information. Under the Security Rule, providers are obligated to safeguard their patients' health information from improper use or disclosure and to maintain the integrity of the information and ensure its availability. Both rules apply to PHI, defined as any physical or mental health information created, received, or stored by a **covered entity** that can be used to identify an individual patient, regardless of the form of the health information (i.e., it can be electronic, handwritten, or verbal) (Legal Information Institute, 2013). Covered entities include hospitals and other healthcare providers that transmit any health information electronically as well as health insurance companies and healthcare clearinghouses (Legal Information Institute, 2013).

Clinicians have become very knowledgeable about the requirements of the Privacy and Security Rules. They are familiar with their obligations to protect patient information and the rights afforded to their patients under these regulations:

- Patients are entitled to a notice of privacy practices from their healthcare provider.
- Inpatients are entitled to opt out of the facility's directory, thereby protecting disclosure of information that they are even a patient in the facility.
- Under certain circumstances, patients must authorize disclosure of their PHI before it can be released by the provider.
- Patients can request and obtain access to their own healthcare records and may request that corrections and additions be made to their records. Providers must consider a patient's request to amend a healthcare record, but they are not required to make such an amendment if the request is unwarranted.
- Unauthorized access or use or any loss of healthcare information must be disclosed to any patient affected by the breach.
- Patients may request an accounting of anyone who accessed their healthcare information, and the provider is required to provide that information in a timely manner.
- Patients have a right to complain if they perceive that the privacy or security of their healthcare information has been compromised in some way. Such complaints can be made directly to the provider or to the **Office for Civil Rights (OCR)**.

The OCR, which is part of HHS, is responsible for enforcing HIPAA. It provides significant information and guidance to clinicians who must comply with the Privacy and Security Rules. It has been tracking complaints and investigating violations since 2003. Guidance and information about the complaint process and the violations that the OCR has handled are available on its website at www.hhs.gov/hipaa/filing-a-complaint/index.html. As an example,

snooping of healthcare records of friends and neighbors is a common HIPAA violation. Even if the information is not disclosed to anyone else, it is still a violation to access records of persons whom one is not assigned to care for. Disciplinary actions may include termination (HIPAA Journal, 2023a).

Many businesses are moving to enact a "bring your own device" (BYOD) policy for employees. This policy, which helps to streamline the lives of employees by maintaining personal and business information on one device, can also result in cost savings for the organization overall. BYOD is an issue, however, when dealing with PHI. Healthcare organizations typically do not encourage the use of personal devices for professional matters, and in many instances, they have policies in place forbidding employees from using personal devices in the workplace. According to Pennic (2013), approximately 50% of healthcare organizations reported that personal mobile devices can be used to access the internet within their facilities but these devices were not given access to the organization's network. For a long time, only devices that were issued by the organization, secured, and routinely audited were able to access the secure network; however, workers were not happy carrying more than one device. Kleyman (2018) pointed out that "[i]f we want to keep an effective and productive healthcare workforce, we need to find a balance between connection and control" (para. 7). He suggested several strategies to support workflow and provide appropriate security:

1. Detail and document your users, their mobile interactions, and their use-case
2. Design a mobility and BYOD workflow that works and is secure
3. Leverage EMM/MDM [enterprise mobility management/mobile device management] and mobility control technologies to improve user experience while still locking things down
4. Enable network-level visibility, DLP [data loss prevention], and data scanning (para. 22–25)

As more healthcare workers used personal devices in the workplace, policies began to change to ensure HIPAA **compliance**. Wani et al. (2020) suggested several technologies to address BYOD security risks. These include a mobile device management platform to provide central management of devices, including registration/deregistration, encryption, log off, device tracking and data wiping; containerization to separate personal and organization data; virtual desktop infrastructure that eliminates organizational data storage on personal devices; identity and access management; and secure clinical communication platforms. See this website for a list of ways to handle personal devices and maintain the security of PHI: www.healthit.gov/topic/privacy-security-and-hipaa/how-can-you-protect-and-secure-health-information-when-using-mobile-device.

Compliance with the Privacy and Security Rules is mandatory for all covered entities, and the HITECH Act extends compliance with these requirements directly to other entities that are business associates of a covered entity. Requirements include designation of privacy and information security officials to protect health information and appropriate handling of any complaints. Sanctions must be imposed if a violation of HIPAA occurs. The Privacy and Security Rules also mandated that certain physical and technical safeguards be implemented for PHI and that entities conduct periodic training of all staff to ensure compliance with these safeguards. Most entities adhere to industry standards and provide their personnel with yearly training. In addition, entities are to conduct regular audits to ensure compliance, and any breaches in the privacy or security of PHI must be remedied immediately. It is important to avoid a security incident because such incidents trigger certain notification requirements and may be associated with monetary penalties.

The HITECH Act Enhanced HIPAA Protections

The HITECH Act has had a significant effect on HIPAA's Privacy and Security Rules in the following ways:

- HHS is to provide annual guidance about how to secure health information.
- Notification requirements in the event of a breach in the security of health information were enhanced.
- HIPAA requirements now also apply directly to any business associates of a covered entity.
- The rules that pertain to providing an accounting to patients who want to know who accessed their health information were changed.
- Enforcement of HIPAA was strengthened.

These measures were implemented to provide further assurance that health information would be protected as the country transitioned to a nationwide health IT infrastructure. Privacy and data regulations are also being established around the world. See a map of the world depicting the laws of various countries at this website: https://iapp.org/resources/article/dla-piper-data-protection-laws-of-the-world. It is quite evident that privacy and security are global concerns.

Several standards-setting organizations are also involved in the privacy and security aspects of the health IT infrastructure development (**Box 8-1**).

BOX 8-1 STANDARDS-SETTING ORGANIZATIONS

The following organizations are recognized by the Secretary of Health of HHS as standards-setting organizations and groups that support the administrative simplification aspects of HIPAA. Each organization is followed by a link to its web page. This information is used with permission from www.cms.gov/Regulations-and-Guidance/Administrative-Simplification/HIPAA-ACA/StandardsSettingandRelatedOrganizations.

ADVISORY GROUPS

- National Committee on Vital and Health Statistics (NCVHS)
  - https://ncvhs.hhs.gov
- Workgroup for Electronic Data Interchange (WEDI)
  - www.wedi.org

DESIGNATED AUTHORING ENTITY FOR OPERATING RULES

- Committee on Operating Rules for Information Exchange (CAQH CORE)
  - www.caqh.org/CORE

DESIGNATED STANDARD MAINTENANCE ORGANIZATIONS (DSMOS)

- Dental Content Committee of the American Dental Association (ADA DeCC)
  - www.ada.org/en/science-research/dental-standards/dental-content-committee-decc
- Accredited Standards Committee (ASC X12)
  - www.x12.org
- Health Level Seven (HL7)
  - www.hl7.org
- National Council for Prescription Drug Programs (NCPDP)
  - www.ncpdp.org/home
- National Uniform Billing Committee (NUBC)
  - www.nubc.org
- National Uniform Claim Committee (NUCC)
  - www.nucc.org

NON–DESIGNATED STANDARD MAINTENANCE ORGANIZATIONS

- American National Standards Institute (ANSI)
  - www.ansi.org
- Electronic Healthcare Network Accreditation Commission (EHNAC)
  - www.ehnac.org
- Health Industry Business Communications Council (HIBCC)
  - www.hibcc.org

- Electronic Payments Association (Nacha)
  - www.nacha.org
- National Association of Insurance Commissioners (NAIC)
  - https://content.naic.org
- National Information Standards Organization (NISO)
  - www.niso.org

Avoiding security incidents has become a paramount concern for healthcare organizations and providers. Providers must protect their information and prevent unauthorized persons from accessing, using, disclosing, changing, or destroying a patient's health information or otherwise interfering with the operations of a health information system, such as an EHR. PHI can be secured through encryption, shredding and other forms of complete destruction, or electronic media sanitation. For an overview of two methods for de-identifying PHI, visit www.hhs.gov/hipaa/for-professionals/privacy/special-topics/de-identification/index.html.

Figure 8-3 depicts some common causes of PHI vulnerabilities.

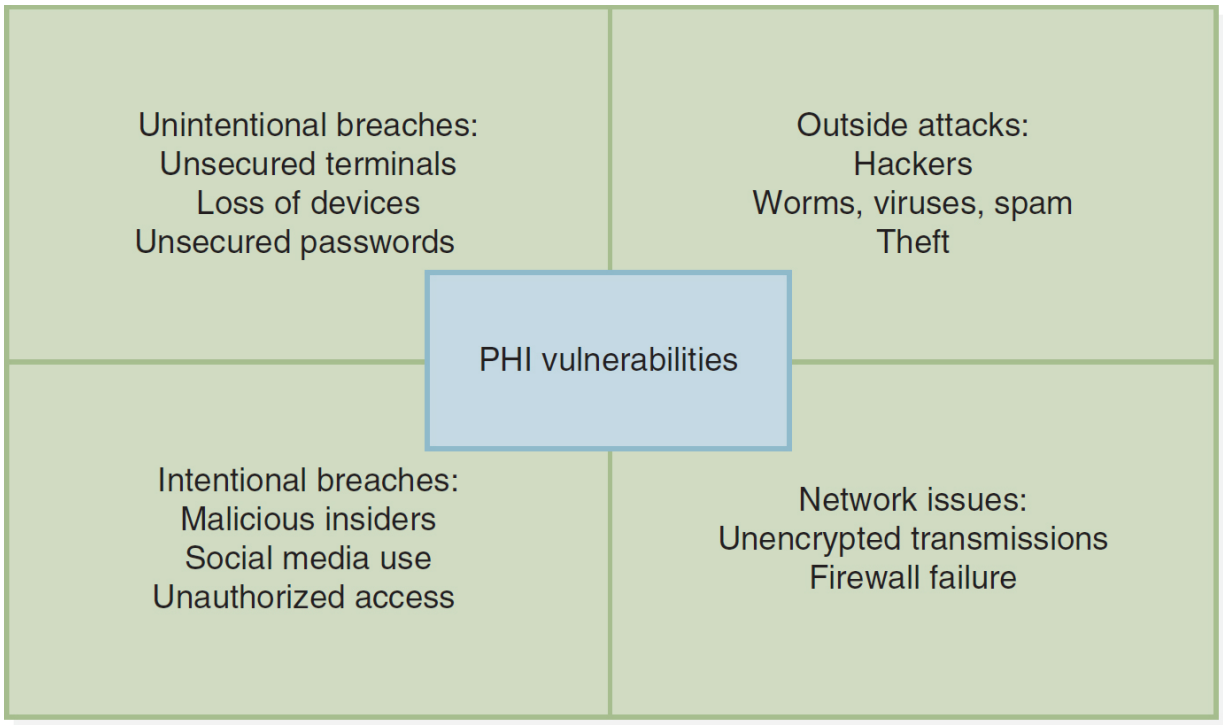


Figure 8-3 Vulnerability of Private Health Information

Description

The distinction between secured and unsecured PHI is important because providers that experience a breach in the privacy or security of their PHI must adhere to certain notification requirements depending on the type of PHI affected by the breach. The HITECH Act enhanced the breach notification requirements of HIPAA. If the PHI is unsecured, the provider must take certain steps to notify those individuals who have been affected. Providers can avoid these onerous breach notification requirements if the PHI is secured in accordance with the specifications of HHS.

A breach is considered discovered as soon as an employee other than the individual who committed the breach knows or should have known of the breach, such as unauthorized access or even an unsuccessful attempt to access information. For example, if a nurse knows that a colleague has accessed or attempted to access the record of a patient for whom the colleague is not providing care, the nurse's employer is deemed to have discovered the breach as soon as the nurse learned of it. The discovery of a breach triggers the beginning of the time frame during which the provider must fulfill the notification requirements. A provider must fulfill these requirements within a reasonable period; under no circumstances may a provider take more than 60 days from discovery of the breach. It is easy to understand why providers require their employees to report knowledge of such breaches immediately to the privacy or information security officer. A provider's failure to adhere to the breach notification requirements could result in OCR sanctions, including monetary penalties.

Whenever a breach involves unsecured PHI, covered entities are responsible for alerting each affected individual by mail or email, based on the individual's preference. If there is insufficient contact information for 10 or more patients, the provider is required to place conspicuous postings on the home page of its website or in major print or broadcast media (without identifying patients). A toll-free number must be provided so that affected individuals can call for

information about the breach. For breaches involving unsecured PHI of more than 500 individuals, a prominent media outlet must also be notified. Notice of a breach must be given to HHS within 60 calendar days of the discovery (HHS, 2015). It is easy to see why providers would want to avoid these requirements by making sure that their PHI is secured. Having to post such notices undermines the trust that exists between healthcare providers and the patients and communities they serve.

The HITECH Act has improved the privacy and security of PHI by applying the requirements of HIPAA directly to the business associates of covered entities. In the past, it was up to the covered entity to enter into contracts with its business associates to ensure compliance with HIPAA. Now business associates are responsible for their own compliance. An example of such a business associate is a health IT company hired by a hospital to implement or upgrade an EHR system. The technology company has access to the hospital's EHR system and must comply with the HIPAA Privacy and Security Rules, just as covered entities must comply with these rules, which includes being subject to enforcement by the OCR for any violations.

Existing accounting rules are enhanced under the HITECH Act, giving patients the right to access their EHR and receive an accounting of all disclosures. Before the HITECH Act, HIPAA regulations provided an exception to the accounting requirements. Providers and other covered entities were not required to include in the accounting any disclosures that were made to facilitate **treatment/payment/operations (TPO)**—treatment of patients, the payment for services, or the operations of the entity—a provision commonly known as the TPO exception. This exception ended in January 2011 for providers that recently implemented new EHR systems. For those providers with EHR systems that were implemented before the HITECH Act, the TPO exception ended in January 2014. It is easy to understand why this exception has ended. As all providers implement comprehensive EHR systems, it will be very easy to generate an electronic record with an accounting of anyone who accessed a patient's record.

Finally, the HITECH Act strengthened the enforcement of HIPAA. HHS can conduct audits, which will be even easier to accomplish once a nationwide health IT infrastructure is in place. In addition, stiffer **civil monetary penalties (CMPs)** for violations of HIPAA became effective as soon as the HITECH Act became law in February 2009. They were revised in 2019 to reduce the maximum penalty for Tiers 1 through 3. CMPs are divided into four tiers. A Tier 1 CMP, in which the covered entity had no reason to know of a violation, is $100 per incident, up to a cap of $25,000 per year. A Tier 2 CMP, in which the covered entity had reasonable cause to know of a violation, is $1,000 per incident, up to a cap of $100,000 per year. A Tier 3 CMP, in which the covered entity engaged in willful neglect that resulted in a breach, is $10,000 per incident, up to a cap of $250,000 per year. In addition, the HITECH Act gives authority to impose an additional Tier 4 CMP of $50,000 to $1.5 million if the covered entity does not properly correct a violation. Criminal penalties also can be imposed when warranted. It is imperative that providers avoid these penalties (HHS, 2019). The HIPAA Journal (2023b) notes that the OCR has discretion when applying penalties and that the actual dollar amounts change yearly with inflation.

Before enactment of the HITECH Act, the federal government alone enforced HIPAA. Now state attorneys general can play a significant role in the enforcement and prosecution of HIPAA violations. Once the HITECH Act became law, state attorneys general were authorized to pursue civil claims for HIPAA violations and collect up to $25,000 plus attorneys' fees. As of 2012, individuals who are damaged by such violations became eligible to share in any monetary awards obtained by these state officials. For very specific and current HIPAA information, see www.hhs.gov/hipaa/index.html.

Interestingly, during the COVID-19 pandemic, the Secretary of Health and Human Services issued a limited waiver of HIPAA sanctions and penalties in response to the declaration of a national emergency. Read here the bulletin detailing HIPAA requirements and limited sanctions during a national emergency: www.hhs.gov/sites/default/files/hipaa-and-covid-19-limited-hipaa-waiver-bulletin-508.pdf.

Implications for Nursing Practice

Being Involved and Staying Informed

The development and implementation of a nationwide EHR system holds great promise for nursing practice and NI. The profession of nursing will benefit from the many enhancements such an infrastructure has to offer, including the ability to improve the delivery and quality of nursing care, making more efficient and timely nursing care decisions for patients, avoiding errors that may harm patients, and promoting health and wellness for the patients whom nurses serve. On a broader scale, nurse researchers will have the ability to more readily access data that can be used to continue to foster evidence-based practice. For those who devote their professional careers to NI or plan to do so, the opportunities abound. Much work remains to be done as this country transitions to a nationwide health IT infrastructure.

All nurses need to be engaged in this process, whether they treat patients, are managers within healthcare organizations, teach, develop computer programs, or help create institutional or governmental policies. Nurses, as the end users of developing technologies, cannot afford to be left behind in these exciting times. Their voices must be heard, whether within the facility in which they work as changes to the EHR system are contemplated or in the public policy arena. How often are nurses the last to know that a new EHR system has been adopted by their hospital? How many times have nurses been trained to use a system that would have benefited from their input before it was implemented or even purchased? Often, nurses are not invited to the table when entities make decisions about informatics. They should not be afraid to ask to be included, whether to be heard within the workplace or within the governmental agencies that are overseeing the changes that are taking place.

Even nurses who do not get involved in this process need to stay current with the rapid changes that are taking place. Information about federal initiatives is available from the ONC and the OCR. Both offices are housed within HHS and are excellent resources for additional information about the HITECH Act and HIPAA. Regulations to implement the HITECH Act and enhance the HIPAA protections required by it are being proposed and adopted at a rapid pace.

Protecting Yourself

Nurses who strive to protect the privacy and security of patient information are protecting themselves from ethical lapses and violations of law. The American Nurses Association's (ANA's) Code of Ethics for Nurses with Interpretive Statements mandates that nurses protect a patient's rights to privacy and confidentiality.

Associated with the right to privacy, the nurse has a duty to maintain the confidentiality of all patient information. Nurses who engage with social media need to be especially cognizant of the potential for breaching the confidentiality of patient information. **Box 8-2** provides more information related to nurses' use of social media. Refer also to the ethical use of social media discussed in Chapter 5, *Ethical Applications of Informatics*. The patient's well-being could be jeopardized and the fundamental trust between patient and nurse destroyed by unnecessary access to data or the inappropriate disclosure of identifiable patient information. The rights, well-being, and safety of the individual patient should be the primary factors in arriving at any professional judgment concerning the disposition of confidential information received from or about the patient, whether oral, written, or electronic. The standard of nursing practice and the nurse's responsibility to provide quality care require that relevant data be shared with only those members of the healthcare team who have a need to know that information. Only information pertinent to a patient's treatment and welfare should be disclosed and only to those directly involved with the patient's care.

When using electronic communications, special effort should be made to maintain data security (ANA, 2015).

BOX 8-2 USE OF SOCIAL NETWORKS BY NURSES

New opportunities to share information via social networks have grabbed the headlines. Since their inception in 2004, the growth in popularity of social networking platforms, such as Facebook (www.facebook.com) and X (formerly Twitter) (www.twitter.com), has been phenomenal. What makes these sites so attractive? Web-based applications, such as Facebook, allow users to connect and share information in ways that were not previously possible. Users develop online profiles that contain information they choose to share with others. Using simple online utilities, users can easily connect and share their profiles and communicate with friends over the internet. Virtual groups of users with similar profiles may be created, connecting users with others who have similar interests. X (Twitter), a microblogging platform, allows users to create interpersonal networks for socializing, support, and information sharing. The power of such tools as X (Twitter) lies in their being lightweight, their limiting of updates to 280 or fewer characters, and their convenience—users can update their status from any device that has an internet connection or text messaging capabilities.

The popularity of social and mobile networking applications is one indication of how new web-based technologies are changing communication preferences. The web is no longer a destination place but instead has become a vehicle of communication where individuals use application software (app), which is installed or downloaded, to connect with others. Individuals act as their own portal and can connect from anywhere with their various communities. This makes it difficult to separate communities and social networks. Where once it was relatively easy to separate work relationships from friends and family, networked communities tend to overlap, which blurs the boundaries between them. The phenomenon of overlapping networks means that the unintended audience is almost always greater than the intended one. A status update that may be construed as harmless and funny to one's friends could be taken in an entirely different way by family or colleagues. This is not to say networked communities are harmful or bad. Indeed, the benefits of such communities far exceed their negatives. However, the immediacy and permanence of the updates shared mean that the user must think about the impact beyond the intended audience in ways never before required (Johnson & Swain, 2011).

Nurses and other healthcare workers who use social media must be aware that the overlapping of networks may unintentionally create privacy and confidentiality breaches. Even when patients are not identified by name, general sharing of information or venting about a difficult day may constitute a privacy breach. The National Council of State Boards of Nursing (2011) has collaborated with the ANA in a white paper to develop specific guidelines for the use of social media by nurses. Read the white paper discussing common misconceptions about social media, consequences for breaching confidentiality using social media, guidelines for appropriate use of social media, and case scenarios with discussion.

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The similarities between these ethical obligations and the legal requirements of HIPAA and other federal and state privacy and confidentiality laws are readily apparent to nurses. By complying with their ethical code, nurses were complying with the Privacy and Security Rules before they were required to do so. Since the adoption of the HIPAA Privacy and Security Rules and the strengthening of the rules by the HITECH Act, it is more important than ever for nurses to understand their obligations in this area and to avoid the pitfalls of violations.

In addition to the sanctions imposed by the OCR, violations can lead to disciplinary actions, as well as litigation, by employers and professional licensing boards. Such actions can have a serious negative effect on the nurse's reputation and financial well-being. If a nurse is terminated for invading a patient's privacy or breaching the confidentiality of a patient's information, some state laws require reporting the information to prospective employers of the nurse; other laws require reporting the information to the state board of nursing. State boards of nursing have the authority to publicly discipline a nurse who has engaged in professional misconduct by

invading a patient's privacy, which includes inappropriately accessing a patient's EHR and breaching confidentiality of patient information, such as allowing or tolerating unauthorized access to a patient's EHR. These types of situations can also cause patients to file complaints with the OCR and lawsuits against the offenders. Nurses must be ever mindful of their obligation to report a breach in the privacy or security of PHI to their employers, even if it entails reporting a colleague.

Finally, some view the EHR as a convenient method for employers to monitor the performance of their nurses. Clearly, an EHR system provides a wealth of information that can be, and often is required to be, monitored. Audits are required to make sure that no breaches in the system's security occur. Audits are not necessarily required to determine, for example, which nurses are failing to complete the hospital's documentation requirements in a timely fashion, which nurses are improperly altering (attempting to correct) the record, or which nurses are dispensing more pain medication than the average. Nurses have been challenged by employers who allege failure to document, improper or false documentation, and suspected diversion of narcotics. These types of situations are unsettling and may be on the rise as more providers adopt sophisticated EHR systems. Thus, it behooves every nurse who works with such a system to obtain proper training and to know the policies and procedures that pertain to its use.

Social media can and should be used in an appropriate manner by professionals to educate and promote health behaviors in the clients they serve, communicate with clients if they choose this method of communication, and network with other professionals by sharing information (de-identified) and knowledge. As Gagnon and Sabus (2015) suggested, "the reach of social media for health and wellness presents exciting opportunities for the health care professional with a well-executed social media presence. Social media give health care providers a far-reaching platform on which to contribute high-quality online content and amplify positive and accurate health care information and messages. It also provides a forum for correcting misinformation and addressing misconceptions" (p. 410). They

advocated for healthcare professionals to practice digital professionalism and for social media use to be one of the professional competencies for health professional education. Bazan (2015) suggested that social media can be used to consult with other healthcare providers, such as in a professional Facebook group, using direct private messaging between the two providers, but cautioned that posting to the main social site cannot contain any hint of PHI. He also shared information about a progressive medical practice that communicates with patients via private messaging on Facebook. Pershad et al. (2018) suggested that X (Twitter) is a great collaborative and communication tool for patients, physicians, and researchers. They caution, however, that dangerous misinformation can also be shared by nonexperts on this platform. Remember that everything you do electronically leaves a digital footprint. Proceed with caution and be certain that your digital interactions comply completely with professional ethics, laws, and organizational policies.

Recent Laws and Regulations

In 2015, MACRA (HHS, 2016) was released by CMS. Although this legislation primarily affects provider payments based on quality care, all members of the healthcare team will have a hand in helping to ensure quality care. This new legislation replaced the former CMS meaningful use guidelines and rewards clinicians for value over volume. A key component of this legislation was the replacement of Social Security numbers on Medicare cards by April 2019 (CMS, n.d.-b). Updates to this legislation and implementation rules and guidelines can be found at the CMS website at www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/MACRA-MIPS-and-APMs/MACRA-MIPS-and-APMs.

The U.S. Food and Drug Administration (FDA), a division of HHS, is responsible for regulating medical devices to ensure public safety. In 2015, in response to the proliferation of mobile medical applications, the FDA released a guidance document for manufacturers, developers, and FDA staff, which was revised in 2019 and again in 2022. Currently, the most common types of these mobile or smartphone-based apps are not regulated by the FDA because they are not defined as medical devices. An app is defined as a medical device and may be subject to regulation by the FDA if "the intended use of a mobile app is for the diagnosis of a disease or other conditions, or the cure, mitigation, treatment, or prevention of disease, or if it is intended to affect the structure or function of the body of man" (FDA, 2022, p. 8). The guidance document also provides a list of examples of apps that are not currently viewed as medical devices, such as apps that help users organize personal medical data, track fitness, or self-manage a disease. If, however, the mobile app is an accessory to a regulated medical device, then it is also considered a medical device and is subject to FDA oversight. For those who are interested in developing mobile health apps in the future, the FDA provides an interactive website to help determine

whether the device would need to be regulated (www.ftc.gov/tips-advice/business-center/guidance/mobile-health-apps-interactive-tool). We must be aware that as these mobile apps become more sophisticated in the future, they may indeed be subject to more stringent oversight by the FDA to ensure consumer safety.

The 21st Century Cures Act signed into law in 2016 contains several provisions that are specific to informatics. In general, the Cures Act was designed to provide funding streams and promote research into preventing and curing serious illnesses, ensure medication and medical device development, support community mental health efforts, and improve interoperability and health information exchange by providing seamless access to improved EHRs. Interestingly, there is a provision barring the FDA from regulating mobile health apps that support wellness as long as the app does not diagnose or treat disease. The act also clarifies HIPAA privacy rules when a patient is incapacitated and unable to make decisions (Lengyel-Gomez, 2017). The most interesting part of the Cures Act is the focus on interoperability by requiring a standardized application programming interface (API), creating a Trusted Exchange Network, and forbidding the blocking of health information exchanges. These items are detailed in the Cures Act Final Rule, which puts patients at the center so that IT will do the following:

- Enable patients to make choices that work for them by increasing transparency into the cost and outcomes of care
- Allow patients to shop for and understand their options in getting medical care
- Provide patients with convenient, easy access and visualizations of health information through smartphone apps
- Support an "app economy" that provides innovation and choice to patients, physicians, hospitals, payers, and employers (ONC, n.d.-d, para. 5)

Stay tuned for HIPAA Privacy Rule changes likely to be announced in mid-2023. According to Clark (2023), the stated reasons for the

2023 Privacy Rule changes include

- Strengthening patient rights to access their own PHI,
- Managing information sharing for care coordination and case management,
- Family and caregiver involvement for individuals experiencing emergencies and health crises,
- Providing guidance for disclosures of PHI to facilitate patient care during an emergency situation, and
- Reducing administrative burden (para. 6)

The Kaiser Family Foundation periodically publishes the U.S. Global Health Legislation Tracker, which provides a list of legislation being considered by Congress. Access the tracker at www.kff.org/coronavirus-covid-19/fact-sheet/u-s-global-health-legislation-tracker.

Summary

The HITECH Act and the HIPAA Privacy Rule and Security Rule are intended to enhance the rights of individuals. These laws provide patients with greater access and control over their PHI. They can control its uses, dissemination, and disclosures. Covered entities must establish not only a required level of security for PHI but also sanctions for employees who violate the organization's privacy policies and administrative processes for responding to patient requests regarding their information. Therefore, they must be able to track the PHI, note access from the perspective of which information was accessed and by whom, and identify any disclosures. Finally, readers should recognize that there is global awareness of the need for privacy protections for personal information or PHI.

Over the next few years, international efforts will accelerate to enhance international data exchange. We will come to appreciate the importance of data and terminology standards that support seamless exchange. We may also see additional legislation designed to safeguard PHI while at the same time enhancing and enabling the use of healthcare data to promote health.

THOUGHT-PROVOKING QUESTIONS

1. One of the biggest problems with healthcare information security has always been inappropriate use by authorized users. How do HIPAA and the HITECH Act help to curb this problem?
2. How do you envision privacy rules, HIPAA, and the HITECH Act evolving in the next decade?
3. If you were the privacy officer in your organization, how would you address the following?
   a. Tracking each point of access of the patient's database, including who entered the data
   b. Encouraging employees to report privacy and security breaches

c. The healthcare professionals are using smartphones, iPads, and other mobile devices. How do you address privacy when data can literally walk out of your setting?

d. You observe one of the healthcare professionals using their smartphone to take pictures of a patient. They see you and, in front of the patient, say, "I am not capturing their face!" How do you respond to this situation?

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SECTION III
Nursing Informatics Administrative Applications: Precare and Care Support

Chapter 9 Systems Development Life Cycle: Nursing Informatics and Organizational Decision-Making

Chapter 10 Administrative Information Systems

Chapter 11 The Human–Technology Interface

Chapter 12 Electronic Security

Chapter 13 Achieving Excellence by Managing Workflow and Initiating Quality Projects

Nursing informatics (NI) and information technology (IT) have invaded nursing, and some nurses are happy with the capabilities afforded by this specialty. Others, however, remain convinced that the changes wrought by IT are nothing more than a nuisance. In the past, nursing administrators have found the implementation of technology tools to be an expensive venture with minimal rewards. This disappointment is likely related to their lack of knowledge about NI, which caused nursing administrators to listen to vendors or other colleagues; in essence, it was decision-making based on limited and biased information. There were at least two reasons for the experience of limited rewards. First, nurses were rarely included in the testing and implementation of products designed for nurses and nursing tasks and workflows. Second, the new products they purchased had to interface with old, legacy systems that were not at all compatible or that seemed compatible until the glitches arose. These glitches caused frustration for clinicians and administrators alike. They purchased tools that should have made the nurses happy, but instead all they did was grumble.

The good news is that approaches have changed as a result of the difficult lessons learned from the early forays into technology tools. Nursing personnel are involved at both the agency and the vendor levels in the decision-making process and development of new systems and products charged with enhancing the practice of nursing. Older legacy systems are being replaced with newer systems that have more capacity to interface with other systems. Nurses and administrators have become more astute in the realm of NI, but there is still a long way to go. Chapter 9, *Systems Development Life Cycle: Nursing Informatics and Organizational Decision-Making*, introduces the systems development life cycle, which is used to make important and appropriate organizational decisions for technology adoption.

Administrators need information systems that facilitate their administrative role, and they particularly need systems that provide financial, risk management, quality assurance, human resources, payroll, patient registration, acuity, communication, and scheduling functions. The administrator must be open to learning about all the tools available. One of the most important tasks that an administrator can oversee and engage in is data mining, or the extraction of data and information from big data, which are sizable data sets that have been collected and warehoused. Data mining helps to identify patterns in aggregate data; gain insights; and, ultimately, discover and generate knowledge applicable to nursing science. To take advantage of these benefits, nursing administrators must become astute informaticists—knowledge workers who harness the information and knowledge at their fingertips to facilitate the practice of their clinicians, improve patient care, and advance the science of nursing.

Clinical information systems (CISs) have traditionally been designed for use by one unit or department within an institution. However, because clinicians working in other areas of the organization need access to this information, these data and information are generally used by more than one area. New

initiatives continue to arise with the integration and enhancement of the electronic health record, which places institutions in the position of striving to manage their CISs through the electronic health record. Currently, there are many CISs, including nursing, laboratory, pharmacy, monitoring, and order entry plus additional ancillary systems, to meet the individual institution's needs. Chapter 10, *Administrative Information Systems*, provides an overview of administrative information systems and helps the reader to understand the powerful data aggregation and data mining tools afforded by these systems.

Chapter 11, *The Human–Technology Interface*, discusses the need to significantly improve quality and safety outcomes in the United States. Through the use of IT, the designs for human–technology interfaces can be radically improved so that the technology better fits both human and task requirements. A number of useful tools are currently available for the analysis, design, and evaluation phases of development life cycles and should be used routinely by informatics professionals to ensure that technology better fits both task and user requirements. In this chapter, the authors stress that the focus on interface improvement using these tools has dramatically improved patient safety in a specific area of health care: anesthesiology. With increased attention from informatics professionals and engineers, the same kinds of improvements are being made in other areas. The human–technology interface is a crucial area if the theories, architectures, and tools provided by the building block sciences are to be implemented.

Each organization must determine who can access and use its information systems and provide robust tools for securing information in a networked environment. Chapter 12, *Electronic Security*, addresses the important safeguards for protecting information. As new technologies designed to improve interprofessional collaboration and enhance patient care are adopted, barriers to implementation and resistance by practitioners to change are frequently encountered. Chapter 13, *Achieving*

Excellence by Managing Workflow and Initiating Quality Projects, provides insights into clinical workflow analysis and advice on improving efficiency and effectiveness while reviewing what we have learned as we tried to achieve meaningful use of caring technologies. The Patient Room 'Next' (PRN) initiative is reviewed. Any new technology implementation will affect work processes and disrupt workflow. Attention must be paid to this effect, and strategies must be implemented to minimize negative effects. Quality improvement projects are focused on improving work processes and patient safety after technologies have been implemented. Quality improvement projects employ many of the same strategies and metrics used in workflow analyses.

Pause to reflect on the Foundation of Knowledge model (**Figure III-1**) and its relationship to both personal and organizational knowledge management. Consider that organizational decision-making must be driven by appropriate information and knowledge developed in the organization and applied with wisdom. Equally important to adopting technology within an organization is the consideration of the knowledge base and knowledge capabilities of the individuals within that organization. Administrators must use the system development life cycle wisely and must carefully consider organizational workflow as they adopt NI technology for meaningful use.

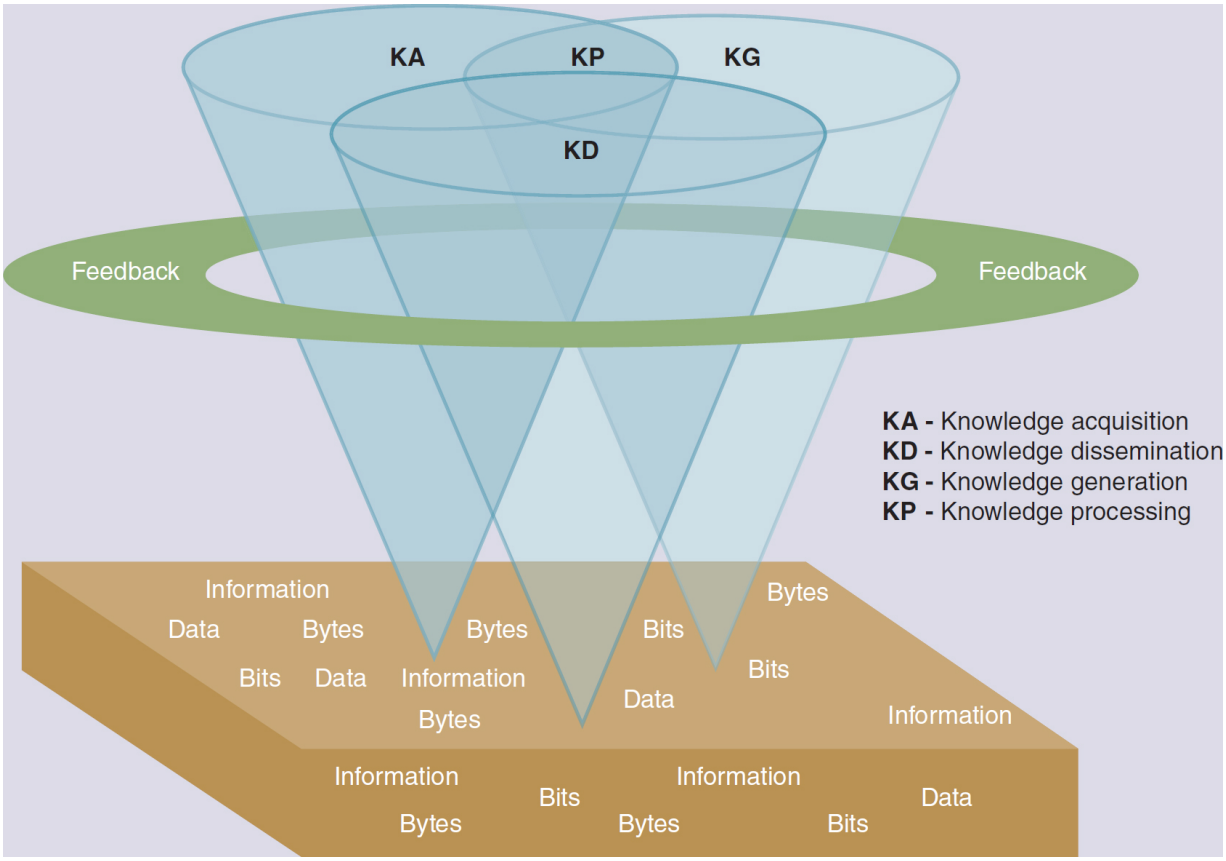


Figure III-1 Foundation of Knowledge Model

Description

The reader of this section is challenged to ask the following questions: (1) How can I apply the knowledge gained from my practice setting to benefit my patients and enhance my practice? (2) How can I help my colleagues and patients understand and use the current technology that is available? and (3) How can I use my wisdom to create the theories, tools, and knowledge of the future?



CHAPTER 9

Systems Development Life Cycle: Nursing Informatics and Organizational Decision-Making

OBJECTIVES

1. Describe the systems development life cycle (SDLC).
2. Explore selected approaches to the SDLC.
3. Assess interoperability and its importance in addressing and meeting the challenges of implementing the HITECH Act in health care.
4. Reflect on the past to move forward into the future to determine how new systems will be developed, integrated, and made interoperable in health care.

KEY TERMS

- agile
- chief information officer
- computer-aided software engineering (CASE)
- dynamic system development method (DSDM)
- end user
- free/libre open source software (FLOSS)
- free/open source software (F/OSS or FOSS)
- health management information system

- hospital information system (HIS)
- information technology (IT)
- integration
- interoperability
- iteration
- milestone
- MoSCoW
- object-oriented systems development (OOSD)
- open source software (OSS)
- prototype
- rapid application development (RAD)
- rapid prototyping
- repository
- Scrum
- Scrum master
- Scrum team
- systems development life cycle (SDLC)
- TELOS strategy
- total cost of ownership (TCO)
- waterfall model

Introduction

The following case scenario describes the development of rural clinics with an integrated data collection and processing system demonstrating the need to have all stakeholders involved from the beginning to the end of a **systems development life cycle (SDLC)**. Creating the right team to manage system development is key. Various methodologies have been developed to guide this process. This chapter reviews the following approaches to the SDLC: waterfall; rapid prototyping, or rapid development (RAD); object-oriented system development (OOSD); dynamic system development method (DSDM); and agile. When reading about each approach, think about the case scenario and how important it is to understand the specific situational needs and the various methodologies for bringing a system to life. As in the case scenario described later, it is generally necessary or beneficial to use a hybrid approach that blends two or more models for a robust development process.

As the case demonstrates, the process of developing systems, or the SDLC, is an ongoing development with a life cycle. The first step in developing a system is to understand the problems, or business needs. This step is followed by understanding the solution, or how to address those needs; developing a plan; implementing the plan; evaluating the implementation; and, finally, performing plan maintenance, plan review, and system destruction. If a system needs major upgrading outside the scope of the maintenance phase or needs to be replaced because of technological advances or the business needs change, a new project is launched, the old system is destroyed, and the life cycle begins anew.

The SDLC is a way to deliver efficient and effective information systems (ISs) that fit with the strategic business plan of the organization, which stems from its mission. In the world of health care, the development of the IS includes a needs assessment of the entire organization, which should include outreach linkages (as seen in the case scenario) and partnerships and merged or shared

functions. The organization's participating physicians and other ancillary professionals and their offices are included in a thorough needs assessment. When developing a strategic plan, the design must consider the existence of the organization within the larger healthcare delivery system and assess the various factors outside of the organization itself, including technological, legislative, and environmental issues, that affect the organization. The plan must identify the needs of the organization as a whole and propose solutions to meet those needs or a way to address the issues.

The SDLC can occur within an organization or be outsourced or be a blend of the two approaches. With outsourcing, the team hires an outside organization to carry out all or some of the development. Developing systems that truly meet business needs is not an easy task and is quite complex. Therefore, it is common to run over budget and miss **milestones**. When reading this chapter, reflect on the case scenario and, in general, the challenges teams face when developing systems.

CASE SCENARIO

Wellness Alliance was formed from the merger of two large healthcare facilities to better serve the community. Its mission is to establish and manage community health programming that addresses the health needs of the rural, underserved populations in the area. Wellness Alliance would like to establish pilot clinical sites in five rural areas to promote access and provide health care to these underserved consumers. Each clinical site will have a full-time program manager and three part-time employees (i.e., a secretary, a nurse, and a doctor). Each program manager will report to the wellness program coordinator, a newly created position within Wellness Alliance.

Because you are a community health nurse with extensive experience, you have been appointed as the wellness program coordinator. Your directive is to establish these clinical sites within 3 months and report back in 6 months with the following information: (1) community health programs offered, (2) level of community involvement in outreach health programs and clinical site–based programming, (3) consumer visits made to the clinical site, and (4) personnel performance.

You are excited and challenged, but soon reality sets in. You know that you have five sites with five program managers. You need some way to gather vital information from each of them in a similar manner so that the data are meaningful and useful to you as you develop your reports and evaluate the strengths and weaknesses of the pilot project. You know that you need a system that will handle all of the pilot project's information needs.

Your first stop is the **chief information officer** of the health system, a nurse informaticist. You know her from the **health management information system** mini-seminar that she led. After explaining your needs, you share with her the constraint that this system must be in place in 3 months, which is when the sites will be up and running, before you make your report. When she begins to ask questions, you realize that you do not know the answers. All you know is that you must be able to report on which community health programs were offered, track the level of community involvement in outreach health programs and clinical site–based programming, monitor consumer visits made to the clinical site, and monitor the performance of site personnel. You know that you want accessible, real-time tracking, but as far as programming and clinical site–related activities are concerned, you do not have a precise description of either the process or the procedures that will be involved in implementing the pilot or the means by which the clinical sites will gather and enter data.

The chief information officer requires that you and each program manager remain involved in the development process. They assign an **information technology (IT)** analyst to work with you and your team in the development of a system that will meet your current needs. After the first meeting, your head is spinning. The IT analyst has challenged your team not only to work out the process for your immediate needs but also to envision what your future needs will be. At the next meeting, you tell the analyst that your team does not feel comfortable trying to map everything out at this point.

The analyst states that there are several ways to go about building the system and software by using the SDLC. Noticing the blank look on everyone's faces, they explain that the SDLC is a series of actions used to develop an IS. The SDLC is similar to the nursing process in which the nurse must assess, diagnose, plan, implement, evaluate, and revise. If the plan developed in this way does not meet the patient's need or a new problem arises, the nurse either revises and updates the plan or starts anew. Likewise, you will plan, analyze, design, implement, operate, support, and secure the proposed community health system. The SDLC is an iterative process—a conceptual model that is used in project management to describe the phases involved in developing an IS. It moves from assessing feasibility to project initiation, to design analysis, to system specification, to programming, to testing, to implementation, to maintenance, and to destruction—literally from beginning to end.

As the IT analyst describes this process, once again they see puzzled looks. They quickly state that even the destruction of the system is planned—that is, how it will be retired, broken down, and replaced with a new system. Even during upgrades, destruction tactics can be invoked to secure the data and even decide whether servers are to be disposed of or repurposed. The security people will tell you that this is their phase where they make sure that any sensitive information is properly handled and decide whether the data are to be securely and safely archived or destroyed.

After reviewing all the possible methods and helping you to conduct your feasibility and business study, the analyst chooses the DSDM. This SDLC model was selected because it works well when the time span is short and the requirements are fluctuating and mainly unknown at the outset. The IT analyst explains that this model works well on tight schedules and is a highly iterative and incremental approach that stresses continual user input and involvement. As part of this highly iterative process, the team will revisit and loop through the same development activities numerous times; this repetitive examination provides ever-increasing levels of detail, thereby improving accuracy. The analyst explains that you will use a mock-up of the **hospital information system (HIS)** and design for what is known; you will then create your own mini-system that will interface with the HIS. Because time is short, the analysis, design, and development phases will occur simultaneously while you are formulating and revising your specific requirements through the iterative process so that they can be integrated into the system.

The functional model **iteration** phase will be completed in 2 weeks, based on the information that you have given the analyst. At that time, the team will review the **prototype**. The IT analyst tells you to expect at least two or more iterations of the prototype based on your input. You should end with software that provides some key capabilities. Design and testing will occur in the design and build iteration phase and continue until the system is ready for implementation, which is the final phase. This DSDM should work well because any previous phase can be revisited and reworked through its iterative process.

One month into the SDLC process, the IT analyst tells the team that they will be leaving their position at Wellness Alliance. They introduce their replacement. The replacement is new to Wellness Alliance and is eager to work with the team. The original IT analyst will be there for one more week to help the new analyst with the transition. When the original analyst explains to the new analyst that you are working through DSDM, they look a bit panicky and state that they have never used this approach. They have used the waterfall, prototyping, iterative enhancement, spiral, and object-oriented methodologies but never the DSDM. From what they have heard, DSDM is new and often runs amok because of the lack of understanding as to how to implement it appropriately. After one week on the project, the new IT analyst

believes that this approach was not the best choice. As the leader of this SDLC, they are growing concerned about having a product ready when the clinical sites open. They might combine another method to create a hybrid approach with which they would be more comfortable; they are thinking aloud and have everyone very nervous.

The IT analyst reviews the equipment that has arrived for the sites and is excited to learn that the computers were ordered from Apple. They will be powerful and versatile enough for your needs.

Two months after the opening of the clinical sites, you, as the wellness program coordinator, are still tweaking the system with the help of the IT analyst. It is hard to believe how quickly the team was able to get a robust system in place. As you think back on the process, it seems so long ago that you reviewed the HIS for deficiencies and screenshots. You reexamined your requirements and watched them come to life through five prototype iterations and constant security updates. You trained your personnel on its use, tested its performance, and made final adjustments before implementation. Your own stand-alone system that met your needs was installed and fully operational on the Friday before you opened the clinic doors on Monday, one day ahead of schedule.

At the end of week one, the IT analyst sends out a meeting invitation to discuss the project and lessons learned. In the invitation, they state that the purpose of the meeting is to review the process, what went well and what did not, and any issues that arose and how they were addressed so that this process can be improved going forward. They stress that this is a meeting to review the process and a time to reflect, not a time to cast blame but instead to look for areas of growth; it can be a time to recognize and praise those who went above and beyond.

The lessons-learned meeting was highly collaborative and energizing since everyone came to the meeting prepared to share their reflections and perspectives openly. Communication was one of the areas where issues arose during development. They discussed how this could have been handled better at the time and offered suggestions for improving communications in subsequent developments. Many of the people in attendance were recognized for their work ethic and positive attitudes throughout the entire project. It was a very positive meeting that did address issues and ideas for improving the process going forward.

You are continuing to evaluate and modify the system, but that is how the SDLC works. It is never finished but rather is constantly evolving.

Waterfall Model

The **waterfall model** is one of the oldest methods and literally depicts a waterfall effect; that is, the output from each previous phase flows into or becomes the initial input for the next phase. This model is a sequential development process in that there is one pass through each component activity from conception, or feasibility, through implementation in a linear order. The deliverables for each phase result from the inputs and any additional information that is gathered. There is minimal or no iterative development where one takes advantage of what was learned during the development of earlier deliverables. Many projects are broken down into six phases (**Figure 9-1**), especially small to medium-size projects.

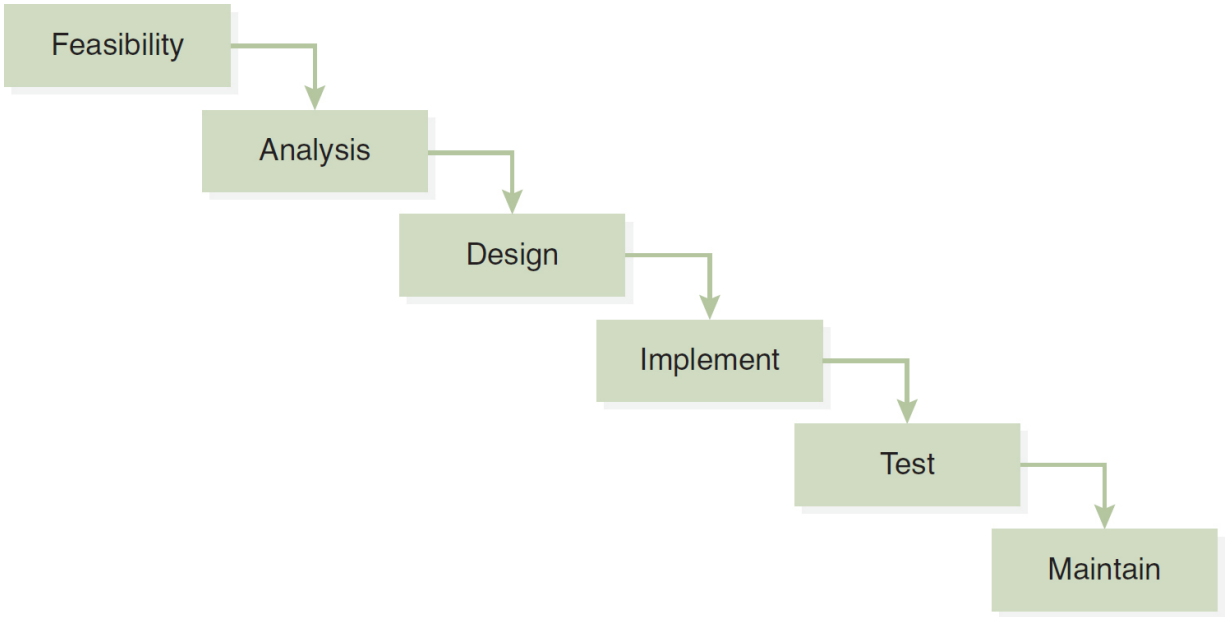


Figure 9-1 Waterfall Phases

Feasibility

As the term implies, the feasibility study is used to determine whether the project should be initiated and supported. This study

should generate a project plan and an estimated budget for the SDLC phases. Often, the **TELOS strategy** (i.e., technological and systems, economic, legal, operational, and schedule feasibility) is followed. Technological and systems feasibility addresses the issues of technological capabilities, including the expertise and infrastructure needed to complete the project. Economic feasibility is determined by performing a cost-benefit analysis, which weighs the benefits versus the costs to determine whether the project is fiscally possible and worth undertaking. Formal assessments should include a return on investment. Legal feasibility assesses the legal ramifications of the project, including current contractual obligations, legislation, regulatory bodies, and liabilities that could affect the project. Operational feasibility determines how effective the project will be in meeting the needs and expectations of the organization and actually achieving the goals of the project or addressing and solving the business problem. Schedule feasibility assesses the viability of the time frame, making sure it is a reasonable estimation of the time and resources necessary for the project to be developed in time to attain the benefits and meet constraints. The TELOS strategy helps to provide a clear picture of the feasibility of the project.

Analysis

During the analysis phase, the requirements for the system are teased out from a detailed study of the business needs of the organization. As part of this analysis, workflows and business practices are examined. It may be necessary to consider options for changing the business process.

Design

The design phase focuses on high- and low-level design and interface and data design. At the high-level phase, team members establish which programs are needed and ascertain how they will

interact. At the low-level phase, team members explore how the individual programs will actually work. The interface design determines what the look and feel will be, or what the interfaces will look like. During data design, the team critically thinks about and verifies which data are required or essential.

The analysis and design phases are vital in the development cycle, and great care is taken during these phases to ensure that the software's overall configuration is defined properly. Mock-ups or prototypes of screenshots, reports, and processes may be generated to clarify the requirements and get the team or stakeholders on the same page, limiting the occurrence of glitches that might result in costly software development revisions later in the project.

Implement

During this phase, the designs are brought to life through programming code. The right programming language, such as C++, Pascal, and Java, is chosen based on the application requirements.

Test

The testing is generally broken down into five layers: (1) the individual programming modules, (2) **integration**, (3) volume, (4) the system as a whole, and (5) beta testing. Typically, the programs are developed in a modular fashion, and the individual modules are then subjected to detailed testing. The modules are subsequently synthesized, and the interfaces between the modules are tested. The system is evaluated regarding its platform and the expected volume of data. It is then tested as a complete system by the team. Finally, to determine whether the system performs appropriately for the user, it is beta tested. During beta testing, users put the new system through its paces to make sure that it does what they need it to do to perform their jobs.

Maintain

Once the system has been finalized from the testing phase, it must be maintained. This could include user support through actual software changes necessitated through use or time.

This model is sequential, with five common stages that must be completed before the next sequential stage begins (Adobe Communications Team, 2022; Isaias & Issa, 2015). This could be considered a disadvantage to system development since no projects are static and changes typically occur during the SDLC. As requirements change, there is no way to address them formally using the waterfall model after project requirements are developed. The waterfall model should be used for simple projects when the requirements are well known and stable from the outset.

Rapid Prototyping, or Rapid Application Development

As technology advances and faster development is expected, **rapid prototyping**, also known as **rapid application development (RAD)**, provides a fast way to add functionality through prototyping and user testing. It is easier for users to examine an actual prototype than documentation. A rapid requirements-gathering phase relies on workshops and focus groups to build a prototype application using real data. This prototype is then beta tested with users, and their feedback is used to perfect or add functionality and capabilities to the system (**Figure 9-2**).

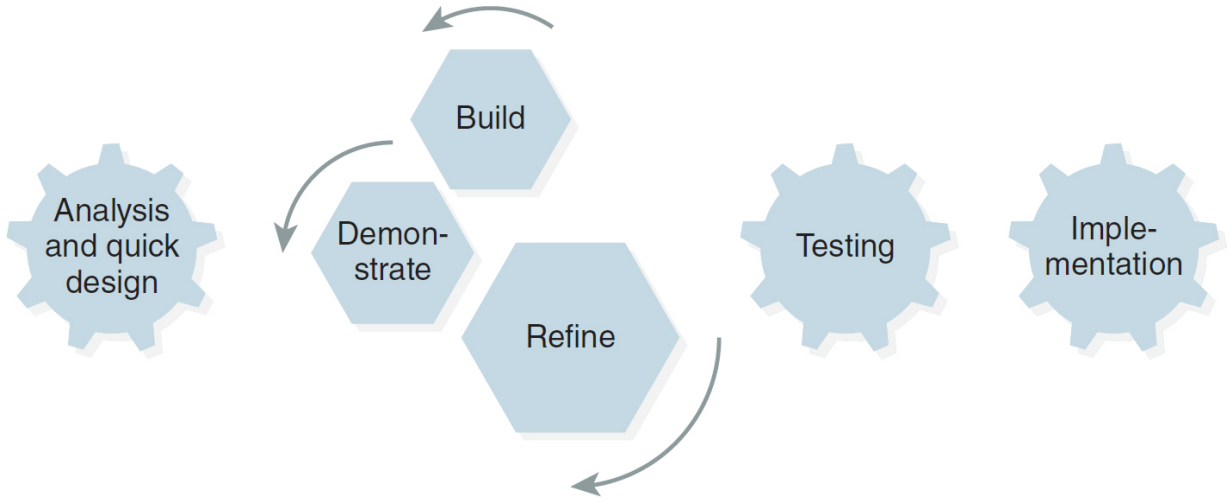


Figure 9-2 Rapid Prototyping, or Rapid Application Development (RAD)

According to Alexandrou (2023), "RAD proposes that products can be developed faster and of higher quality" (para. 1). The RAD approach uses informal communication, repurposes components, and typically follows a fast-paced schedule. Object-oriented programming, using languages such as C++ and Java, promotes software repurposing and reuse.

The major advantage of RAD is the speed with which the system can be deployed; a working, usable system can be built within 3 months. The use of prototyping allows the developers to skip steps in the SDLC process in favor of getting a mock-up in front of the user. At times, the system may be deemed acceptable if it meets a predefined minimum set of requirements rather than all of the identified requirements. This rapid deployment also limits the project's exposure to change elements. Unfortunately, the fast pace can be its biggest disadvantage in some cases. Once one is locked into a tight development schedule, the process may be too fast for adequate testing to be put in place and completed. The most dangerous lack of testing is in the realm of security.

The RAD approach is chosen because it builds systems quickly through user-driven prototyping and adherence to quick, strict delivery milestones. This approach continues to be refined and honed, and other contemporary manifestations of RAD continue to emerge in the agile software development realm.

Object-Oriented Systems Development

The **object-oriented systems development (OOSD)** model blends SDLC logic with object-oriented modeling and programming power to apply object-oriented concepts to all the stages of the SDLC (GeeksforGeeks, 2022; Stair & Reynolds, 2016). It is a method of contemplating and reflecting on problems using models organized around real-world concepts or objects. Object-oriented modeling represents real-world objects by modeling the real-world entities or things (e.g., clinic, patient, account, or nursing or healthcare professional) into abstract computer software objects. Once the system is object oriented, all the interactions or exchanges take place between or among the objects. The objects are derived from classes, and each object comprises data and the actions that can be enacted on that data. Class hierarchy allows objects to inherit attributes from parent classes, which fosters object reuse and results in less coding. The object-oriented programming languages, such as C++ and Java, promote software repurposing and reuse. Therefore, the class hierarchy must be clearly and appropriately designed to reap the benefits of this SDLC approach, which uses object-oriented programming to support the interactions of objects.

For example, in the case scenario, a system could be developed for Wellness Alliance to manage the community health programming for the clinic system being set up for outreach. There could be a class of programs, and *well-baby care* could be an object in the class of programs; *programs* is a relationship between Wellness Alliance and well-baby care. The program class has attributes, such as *clinic site*, *location address*, or *attendees* or *patients*. The relationship itself may be considered an object having attributes, such as *pediatric programs*. The class hierarchy from which all the system objects are created with resultant object interactions must be clearly defined.

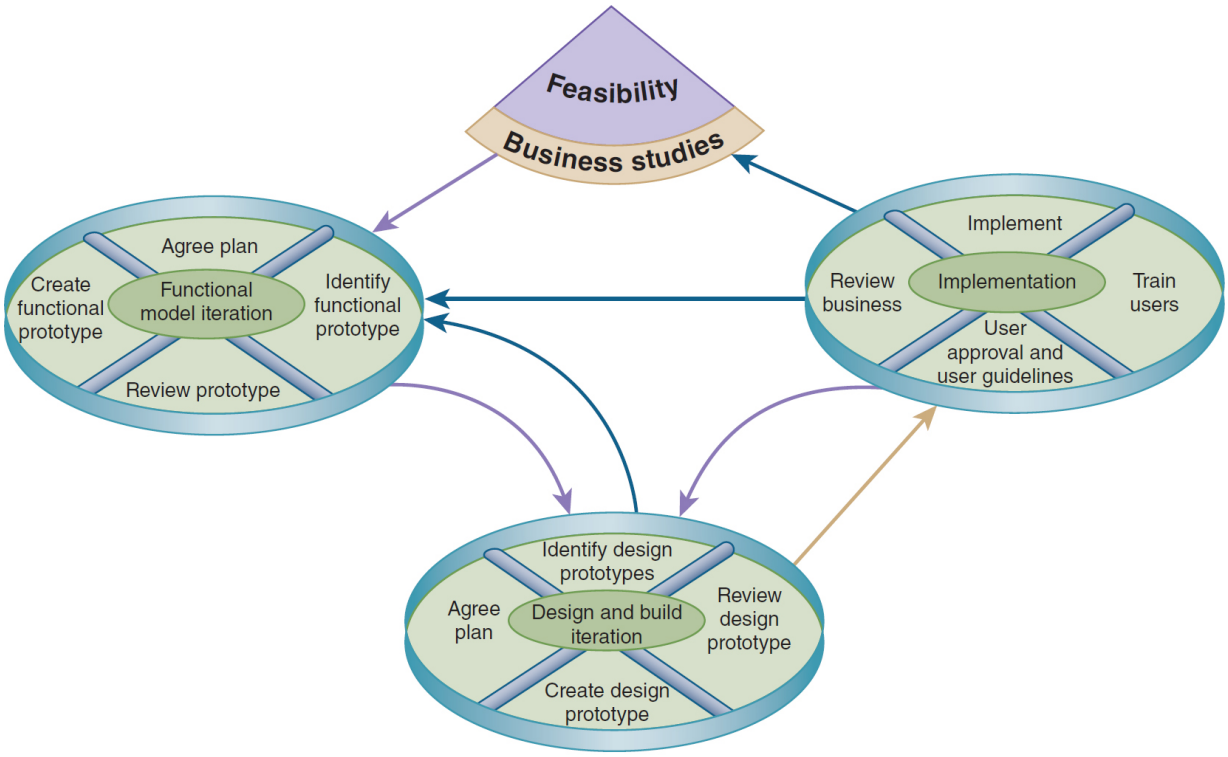
The OOSD model is a highly iterative approach. The process begins by investigating where object-oriented solutions can address

business problems or needs; determining user requirements; designing the system; programming or modifying object modeling (i.e., class hierarchy and objects); and implementing, testing, modifying, and reimplementing the system and ends with the new system being reviewed regularly at established intervals and modifications being made as needed throughout its life.

Dynamic System Development Method

The **dynamic system development method (DSDM)** is a very iterative and incremental approach with a high level of user input and involvement. The iterative process requires repetitive examination that enhances detail and improves accuracy. The DSDM has three phases: (1) preproject, (2) project life cycle (i.e., feasibility and business studies, functional model iteration, design and build iteration, and implementation), and (3) postproject.

In the preproject phase, buy-in is established and funding is secured. This helps to identify the stakeholders (i.e., administration and **end users**) and gain support for the project. In the second phase, the project's life cycle begins. This phase includes five steps: (1) feasibility, (2) business studies, (3) functional model iteration, (4) design and build iteration, and (5) implementation (**Figure 9-3**).



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Figure 9-3 Dynamic System Development Method (DSDM)

Description

In steps 1 and 2, the feasibility and business studies are completed. The team ascertains whether this project meets the required business needs while identifying the potential risks during the feasibility study. In step 1, the deliverables are a feasibility report, project plan, and risk log. Once the project is deemed feasible, step 2, the business study, is begun. The business study extends the feasibility report by examining the processes and the stakeholders' needs. It is important to align the stakeholders with the project and secure their buy-in because it is necessary to have user input and involvement throughout the entire DSDM process. Therefore, bringing them in at the beginning of the project is imperative.

Using the MoSCoW approach, the team works with the stakeholders to develop a prioritized requirements list and a development plan. **MoSCoW** stands for "must have, should have, could have, and would have." The "must have" requirements are necessary to meet the business needs and are critical to the success of the project. The "should have" requirements are those that would be great to have if possible, but the success of the project does not depend on their being addressed. The "could have" requirements are those that would be nice to have met, and the "would have" requirements can be put off until later; these requirements may be undertaken during future developmental iterations. Timeboxing is generally used to develop the project plan. In timeboxing, the project is divided into sections, each having its own fixed budget and milestones for deliverables. The MoSCoW approach is then used to prioritize the requirements within each section; the requirements are the only variables because the schedule and budget are set. If a project is running out of time or money, the team can easily omit the requirements that have been identified as the lowest priority to meet their schedule and budget obligations. This does not mean that the

final deliverable, the actual system, would be flawed or incomplete. Instead, because the team has already determined the "must have" or "should have" items, it still meets the business needs. According to Haughey (2021), the 80/20 rule, or Pareto principle, can be applied to nearly everything. The Pareto principle states that 80% of the project comes from 20% of the system requirements; therefore, the 20% of requirements must be the crucial requirements, or those with the highest priority. One must also consider the pancake principle: The first pancake is not as good as the rest, and one should know that the first development will not be perfect. This is why it is extremely important to clearly identify the "must have" and "should have" requirements.

In the third step of the project life cycle phase, known as functional model iteration, the deliverables are a functional model and prototype ready for user testing. This could take several iterations to develop the desired functionality and incorporate the users' input. At this stage, the team should examine the quality of the product and revise the list requirements and risk log. The requirements are adjusted, the ones that have been realized are deleted, and the remaining requirements are prioritized. The risk log is revised based on the risk analysis completed during and after prototype development.

The design and build iteration step focuses on integrating functional components and identifying the nonfunctional requirements that need to be in the tested system. Testing is crucial; the team will develop a system that the end users can safely use on a daily basis. The team will garner user feedback and generate user documentation. These efforts provide this step's deliverable, a tested system with documentation for the next and final phase of the development process.

In the final step of the project life cycle phase, known as implementation, deliverables are the system (ready to use), documentation, and trained users. The requirements list should be satisfied along with the users' needs. Training users and implementing the approved system are the first part of this phase, and the final part consists of a full review. It is important to review

the effect of the system on the business processes and determine whether it addresses the requirements established at the beginning of the project. This final review determines whether the project is completed or if further development is necessary. If further development is needed, the preceding phases are revisited. If the project is complete and satisfies the users, then it moves into maintenance and ongoing development.

The final phase is labeled postproject. In this phase, the team verifies that the system is functioning properly. Once verified, the maintenance schedule begins. Because the DSDM is iterative, this postproject phase is seen as ongoing development, and any of the deliverables can be refined. This is what makes the DSDM such an iterative development process.

DSDM is one of an increasing number of agile methodologies being introduced, such as Scrum and Extreme Programming. Refer to the following information on the agile method. These new approaches address the organizational, managerial, and interpersonal communication issues that often bog down SDLC projects. Empowerment of teams and user involvement enhance the iterative and programming strengths provided in these SDLC models.

Agile

The **agile** method is different from other approaches to software development since the focus is on "the people doing the work and how they work together. Solutions evolve through collaboration between self-organizing cross-functional teams utilizing the appropriate practices for their context" (Agile Alliance, n.d., para. 7). The agile software development approach merges iterative and incremental process models whereby the product is broken into small incremental builds on which the teams work in short bursts, such as 2- to 4-week intervals, to accomplish their tasks. Failure is considered positive if you fail fast and fail often to get to your goal. This method lends itself well to smaller projects and rapidly delivers functional software to the customer; this quick turnaround enhances customer satisfaction.

Scrum is an agile strategy that emphasizes collaboration, team autonomy, or self-management and flexibility to adapt to emerging business realities. This strategy organizes software developers into a team called a **Scrum team** to reach a common goal of creating market-ready products and services using iterative development cycles. As a framework, it can manage complex knowledge work. Scrum defines roles, procedures, and tools to guarantee the delivery of an effective and efficient product. The three foundational concepts of Scrum are adaptation, transparency, and inspection. The **Scrum master** is the agile servant–leader project manager who facilitates the work performed by the Scrum team; this leader is responsible for removing barriers and obstacles so that tasks may be completed for the team to achieve its goals. The Scrum master must support the Scrum team and facilitate its ability to self-manage and self-organize. Since this is a highly collaborative process, the Scrum master must also establish and ensure a positive environment that is open to discussion and sharing of ideas. In addition, the Scrum master must assess and monitor Scrum team interactions with those outside of the team to determine which exchanges with the Scrum

team are beneficial and which are not in order to maximize the value generated by the Scrum team (i.e., shielding the Scrum team from distractions and work interruptions). The Scrum master guides, protects, coaches, facilitates, and develops the Scrum team to reach its goals of producing high-quality products and service deliverables.

Computer-Aided Software Engineering Tools

When reviewing the SDLC, the **computer-aided software engineering (CASE)** tools that will be used must be described.

CASE is the methodical application of a set of tools that promote adherence to the SDLC process by automating several required tasks, which provides standardization and thoroughness to the total systems to develop quality software systems that are free of defects (Stair & Reynolds, 2016; Waghmare, 2023; Wikibooks.org, 2018). These tools help to reduce cost and development time while enriching the quality of the product. CASE tools contain a **repository** with information about the system: models, data definitions, and references that link models together. Repositories are valuable in their ability to make sure the models follow diagramming rules and are consistent and complete.

The various types of tools can be referred to as upper-CASE or lower-CASE tools. The upper-CASE tools support the analysis and design phases, whereas the lower-CASE tools support implementation. The tools can also be general or specific in nature, with the specific tools being designed for a particular methodology.

Two examples of CASE tools are Visible Analyst and Rational Rose (IBM, 2021). According to Andoh-Baidoo et al. (2009), Visible Analyst "supports structured and object-oriented design (UML)" (p. 372). Rational Rose supports solely object-oriented design (UML), allowing for "side-by-side comparison between the Rose diagrams and the equivalent diagrams in the new Rational UML modeling products" (IBM, 2021, para. 3). Both tools can "build and reverse database schemas for SQL and Oracle" and "support code generation for pre-.NET versions of Visual Basic" (p. 372). Visible Analyst can also support shell code generation for pre-.NET versions of C and COBOL, whereas Rational Rose can support complete code for C++ and Java. In addition, Andoh-Baidoo et al. (2009) found that Rational Rose "[p]rovides good integration with Java, and

incorporates common packages into class diagrams and decompositions through classes" (p. 372).

CASE tools have many advantages, including decreasing development time and producing more flexible systems. On the downside, they can be difficult to customize and use with existing systems.

Open Source Software, Free/Libre Open Source Software, and Free/Open Source Software

Another area that must be discussed with the SDLC is **open source software (OSS)**, **free/libre open source software (FLOSS)**, and **free/open source software (F/OSS or FOSS)**. There are two political camps in the free software community: the free software movement and open source. According to Stallman (2021),

> *The free software movement is a campaign for computer users' freedom; we say that a nonfree program is an injustice to its users. The open source camp declines to see the issue as a matter of justice to the users, and bases its arguments on practical benefits only.* (para. 1)

Free software refers to freedom and not cost and, as a nonpolitical statement, is noted as free/libre, creating the FLOSS abbreviation. Stallworth stated that "[o]thers use the term 'FOSS,' which stands for 'Free and Open Source Software.' This is meant to mean the same thing as 'FLOSS,' but it is less clear, since it fails to explain that 'free' refers to *freedom*" (para. 4).

An examination of job descriptions or advertisements for candidates shows that many IS and IT professionals need a thorough understanding of the SDLC and OSS development tools (e.g., PHP, MySQL, and HTML). With OSS, any programmer can implement, modify, apply, reconstruct, and restructure the rich libraries of source codes available from proven, well-tested products.

As Karopka et al. (2014) noted,

> *Free/Libre Open Source Software (FLOSS) has been successfully adopted across a wide range of different areas and has opened new ways of value creation. Today there are hundreds of examples of successful FLOSS projects and products. . . . Especially in times of financial crisis and austerity the adoption of FLOSS principles opens interesting alternatives and options to tremendously lower **total cost of ownership (TCO)** and open the way for a continuous user-driven improvement process.* (para. 6)

To transform health care, it is necessary for clinicians to use ISs that can share patient data (Goulde & Brown, 2006; HealthIT.gov, 2022; NORC, 2014). Because this all sounds terrific, many people wonder why it has been slowly evolving, not realizing that the challenges are many. How does one establish the networks necessary to share data between and among all healthcare facilities easily and securely? Early attempts at OSS ventures in the healthcare realm failed because of a lack of support for sustained effort, technological lags, lack of authority and credibility, and other such issues. Health care in the United States has been applying FLOSS-HC (health care). OSS is developed to work with everything and facilitates the sharing of data and information, making it essential to interoperability. With OSS, numerous people and entities are working to solve the same or similar problems, affording healthcare organizations access to innovative solutions to their major challenges such as scalability and security.

Health care is realizing the benefits of FLOSS, including vendor independence.

Interoperability

Interoperability, which is the ability to share information across organizations, remains paramount under the HITECH Act. The ability to share patient data is extremely important, both within an organization and across organizational boundaries (**Figure 9-4**).

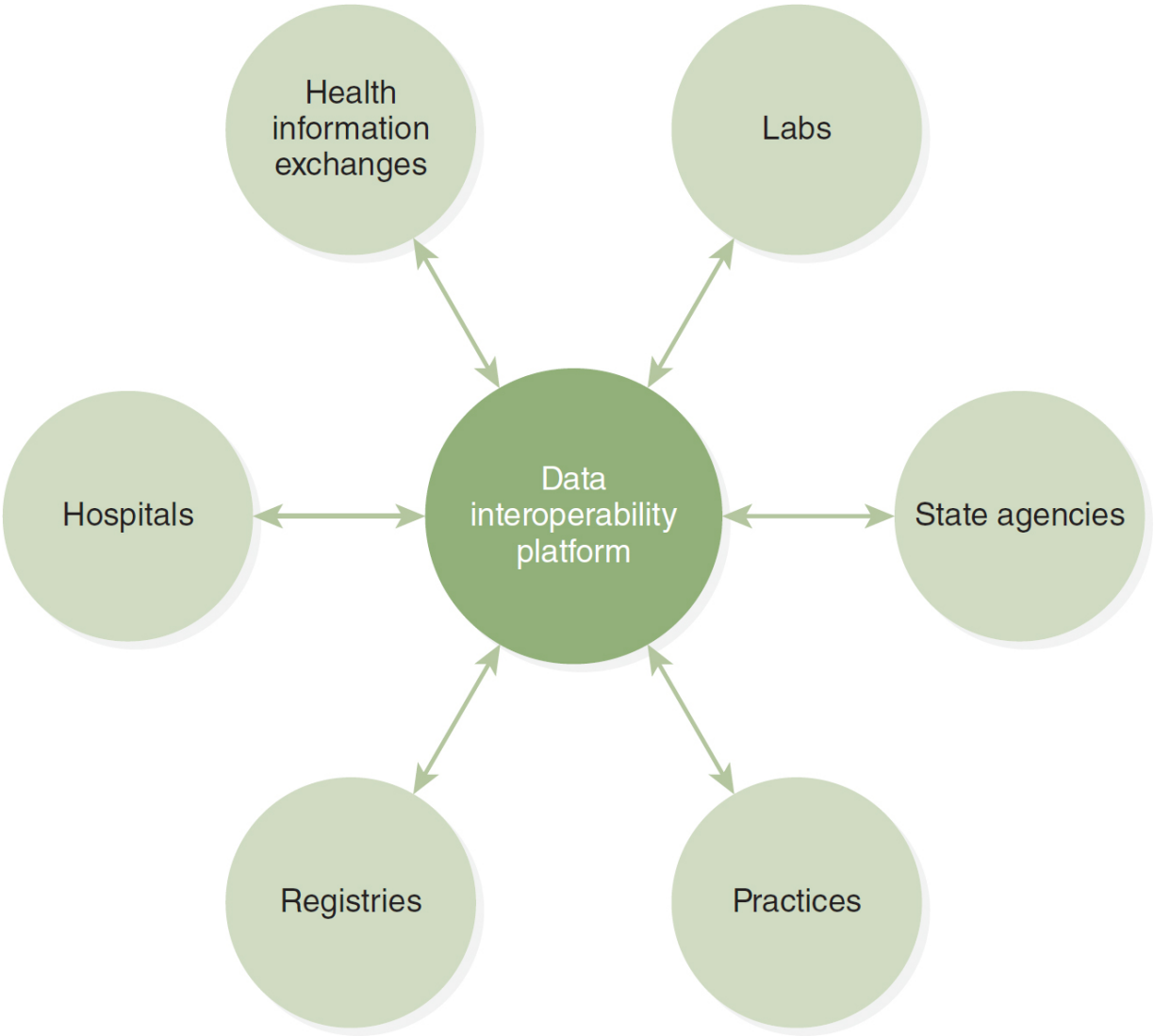


Figure 9-4 Interoperability

According to the Health Information and Management Systems Society (HIMSS; n.d.), there are standards, implementation specifications, and standards-development organizations. These various types of organizations are working to support the development of systems that can seamlessly exchange and use health data. Few healthcare systems take advantage of the full potential of the current state of the art in computer science and health informatics (HIMSS, n.d.). The consequences of this situation include a drain on financial resources from the economy, the inability to truly mitigate the occurrence of medical errors, and a lack of national preparedness to respond to natural and man-made epidemics and disasters. HIMSS created the Integration and Interoperability Steering Committee to guide the industry on allocating resources to develop and implement the standards and technology needed to achieve interoperability.

As we enter into the SDLC, we must be aware of how this type of development will affect both our own healthcare organization and the healthcare delivery system as a whole. In an ideal world, we would all work together to create systems that are integrated within our own organization while having the interoperability to cross organizational boundaries and unite the healthcare delivery system to realize the common goal of improving the quality of care provided to consumers.

Summary

At times during the SDLC, new information affects the outputs from earlier phases; the development effort may be reexamined or halted until these modifications can be reconciled with the current design and scope of the project. At other times, teams are overwhelmed with new ideas from the iterative SDLC process that result in new capabilities or features that exceed the initial scope of the project. Astute team leaders will preserve these ideas so that they can be considered at a later time. The team should develop a list of recommendations to improve the current software when the project is complete. This iterative and dynamic exchange makes the SDLC robust.

As technology and research continue to advance, new SDLC models are being pioneered and revised to enhance development techniques. The interpretation and implementation of any model selected reflect the knowledge and skill of the team applying the model. The success of the project is often directly related to the quality of the organizational decision-making throughout the project—that is, how well the plan was followed and documented. United efforts to create systems that are integrated and interoperable will define the future of health care.

THOUGHT-PROVOKING QUESTIONS

1. Reflect on the SDLC in relation to the quality of the organizational decision-making throughout the project. What are some of the major stumbling blocks faced by healthcare organizations?
2. Why is it important for all nurses and healthcare professionals to understand the basics of how ISs are selected and implemented?
3. Describe the major differences between the agile method and other SDLC approaches. Reflect on why you would select the agile method over the waterfall model, and provide a detailed rationale for your choice.

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CHAPTER 10

Administrative Information Systems

OBJECTIVES

1. Explore agency-based health information systems (ISs).
2. Evaluate how administrators use core business systems in their practice.
3. Assess the function and information output from selected ISs used in healthcare organizations.

KEY TERMS

- acuity system
- admission, discharge, and transfer (ADT) system
- American National Standards Institute (ANSI)
- attribute
- care plan
- case management information system
- clinical documentation improvement (CDI)
- clinical documentation system
- clinical information system (CIS)
- collaboration
- column
- communication system
- computerized physician (or provider) order entry (CPOE) system
- core business system
- database

- database management system
- data dictionary
- data file
- data mart
- data mining
- data warehouse
- decision support
- drill down
- electronic health record (EHR)
- entity
- entity relationship diagram
- field
- financial system
- information system (IS)
- information technology (IT)
- International Organization for Standardization (ISO)
- interoperability
- key field
- knowledge exchange
- laboratory information system
- managed care information system
- order entry system
- patient care information system
- patient care support system
- patient centered
- pharmacy information system
- picture archiving and communication system (PACS)
- primary key
- query
- radiology information system (RIS)
- record
- relational database management system (RDMS)
- repository
- row
- scheduling system

- stakeholder
- standardized plan of care
- Structured Query Language (SQL)
- table
- tiering
- triage
- tuple
- unified communications (UC)

Introduction

To compete in the ever-changing healthcare arena, organizations require quick and immediate access to a variety of types of information, data, and bodies of knowledge for daily clinical, operational, financial, and human resource activities. Information is continually shared between units and departments within healthcare organizations and is also required or requested from other healthcare organizations, regulatory and government agencies, educational and philanthropic institutions, and consumers. Organizations need interoperable systems that are accessible for data storage and retrieval.

But healthcare organizations are distinct from other organizations that use ISs. Fichman et al. (2011) identified six important elements of health care that may explain the lag in the development and implementation of ISs:

- The stakes are life and death.
- Healthcare information is highly personal.
- Health care is highly influenced by regulation and competition.
- Health care is professionally driven and hierarchical.
- Health care is multidisciplinary.
- Healthcare information system implementation is complex, with important implications for learning and adaptation. (pp. 420–423)

Healthcare organizations integrate a variety of clinical and administrative types of **information systems (ISs)**. These systems collect, process, and distribute patient-centered data to aid in managing and providing care. Together, they create a comprehensive **record** of the patient's medical history and support organizational processes. Each of these systems is unique in the way it functions and provides information to clinicians and administrators.

An understanding of how each of these types of systems works within healthcare organizations is fundamental in the study of informatics. This chapter will focus on the administrative organizational systems.

Principles of Interoperability

It is important to realize that ISs of one type or another have been used in healthcare facilities for quite a while. Unfortunately, some of these early systems (sometimes referred to as legacy systems) created data silos; that is, the data and information central to that system remained in that system and could not easily be shared with other systems. A key component to coordinated, patient-centered care is the interoperability of healthcare ISs. **Interoperability** is defined as the ability of various systems and organizations to work together to exchange information. "Interoperability is made possible by the implementation of standards" (IEEE Standards University, 2016, para. 51). To provide continuity of care, data and information about our patients must be accessible and usable so that we are making informed decisions about their care. We also must monitor our patients, and often this requires gathering multiple biometric data from medical devices such as ventilators, blood pressure monitors, weight scales, and glucose monitors. By using IEEE standards, these devices can be interoperable. "A patient can access data from multiple devices at the same time and the provider can monitor all of the data to get a complete view of the patient's health" (IEEE Standards Association, 2023, para. 14). Metadata can be used to describe information about data and digital objects, using terms called *tags*. "Metadata tagging is the process of systematically assigning those tags to the digital assets in an archive or collection, typically using a rules-based system to ensure consistency" (MerlinOne, n.d.).

In 2015, the Office of the National Coordinator for Health Information Technology (ONC) released an interoperability road map to promote ease of access and use of electronic healthcare data. The final goal of the national road map emphasis on interoperability is driven by the need to "achieve nationwide interoperability to enable a learning health system, with the person at the center of a system that can continuously improve care, public health, and science

through real-time data access" (ONC, 2015, p. vii). Since that time, the ONC sunsetted the road map ahead of schedule, but it did help "lay the groundwork and set the direction for policy development on information blocking, reducing provider burden, and nationwide, electronic health information exchange—to name a few" (Posnack, 2021b, para. 3). The Health Interoperability Outcomes 2030 will continue to drive this initiative. As an example, "because of interoperability, faxes are no longer used in clinical care before/by 2030. As another example, because of interoperability, before/by 2030 everyone that is part of a care team will have accurate, up-to-date clinical information prior to providing care" (Posnack, 2021a, para. 7). For more information on the synthesized statements that reflect the public's overall sentiments regarding 2030 outcomes, refer to the website at www.healthit.gov/topic/interoperability/health-interoperability-outcomes-2030. Glickman and Orlova (2022) recapped the standards development work that has been done over the past 16 years. This work has "led the International Organization of Standardization (ISO) Technical Committee 215, Health Informatics (ISO/TC 215) to the practical realization that a 'bundle' of individual standards is required to create interoperable health information technology (health IT) standards that will ensure both adoption and sustainability" (para. 2).

As we develop more sophisticated electronic systems, we are realizing the huge potential benefits of exchanging secure and precise healthcare data. However, in the current landscape, several things need to happen to realize this goal. Chief among them is a worldwide commitment to interoperability. The Healthcare Information and Management Systems Society (HIMSS; n.d.) identified four types of health **information technology (IT)** interoperability—foundational, structural, semantic, and organizational—each with increasing complexity. Foundational interoperability defines the requirements necessary between systems to communicate data, and structural interoperability defines syntax and format to facilitate data exchange. Semantic interoperability is more complex and refers to consistency of clinical terminology and

shared meanings. Finally, organizational interoperability refers to shared trust and consistency of policies and social and legal meanings to facilitate seamless workflows between organizations.

Suppose you have a joint replacement patient who is being discharged from the acute care facility to a rehabilitation center. You create a discharge summary for the patient in a PDF format and send it via a secure electronic exchange to the new facility. The staff at the rehabilitation center is able to read and understand the report, and a staff assistant can scan a copy of the discharge summary into the electronic record of the rehabilitation facility. This is an example of functional interoperability. If each facility uses Health Level 7 standards for data exchange and collects certain minimum data, then it might be possible for some data fields from one facility to populate automatically into an appropriate data field in the other facility. This is an example of structural interoperability. To achieve true sematic interoperability, systems must use the same standardized terminologies, or disparate terminologies must be mapped so that the two systems are able to "talk" to each other to exchange data seamlessly and to populate the data into the appropriate fields in the new system. True sematic interoperability enables machine-to-machine data exchange. The adoption and use will continue to need input from users to hone and evolve the standards so that they continue to meet each user's needs. We must strive to truly create the health interoperability ecosystem that "comprises individuals, systems and processes that want to share, exchange and access all forms of health information, including discrete, narrative and multimedia. Individuals, patients, providers, hospitals/health systems, researchers, payers, suppliers and systems are potential stakeholders within this ecosystem" (HIMSS, n.d., para. 29). It is imperative that every **stakeholder** be included in the "creation, exchange and use of health information and/or data. An efficient interoperability ecosystem provides an information infrastructure that uses technical standards, policies and protocols to enable seamless and secure capture, discovery, exchange and utilization of health information" (HIMSS, n.d., para. 29).

Types of Healthcare Organization Information Systems

Case Management Information Systems

Case management information systems identify resources, patterns, and variances in care to prevent costly complications related to chronic conditions and to enhance the overall outcomes for patients with chronic illness. These systems scan past episodes of treatment and search for trends among the records. Once a trend is identified, case management systems provide **decision support** that promotes preventive care. Care plans are a common tool found in case management systems. A **care plan** is an evidence-based set of care guidelines that outline the course of treatment and the recommended interventions that should be implemented to achieve optimal results. By using a **standardized plan of care**, these ISs present clinicians with treatment protocols to maximize patient outcomes and support best practices. IT in health care is positioned to support the development of interdisciplinary care plans. In the health informatics pathway, Standard 5 deals with documentation, for which AHIMA (2020) stated the importance of actively participating in the "development of query policies that support documentation integrity, and meet regulatory, legal, and ethical standards for coding and reporting" (para. 22). We are all responsible for accurate documentation and being aware of the varied uses of healthcare information. As we interact with the interdisciplinary healthcare team verbally and in writing when we document information about our patients, it is imperative that we adhere to the legal and regulatory standards that promote truthful and ethical reporting methods, resulting in correct and trustworthy data and information.

Case management information systems are especially beneficial for patient populations with a high cost of care and complex health needs, such as the elderly or patients with chronic disease

conditions. Avoiding complications requires identifying the right resources for care and implementing preventive treatments across all medical visits. The more information that can be shared among all types of providers, the more that care planning and decision-making can be coordinated, consistent, and safe. Ultimately, this coordinated care decreases the costs of care for patients with chronic illnesses and supports a better quality of life. Such systems increase the value of individual care while controlling the costs and risks associated with long-term health care. Initially, case managers were employed by hospitals, and they primarily focused on utilization review and discharge planning. Now case managers are practicing in other arenas, including home health agencies and insurance companies (Davis, 2022). Case management systems are increasingly being integrated with electronic health records (EHRs). Information collected by these systems is processed in a way that helps to reduce risks, ensure quality, and decrease costs.

In an effort to promote patient-centered care for the management of chronic diseases, Fico et al. (2016) reported on the development of an information and communication technology platform to support personalized healthcare pathways to manage diabetes. The system they developed and tested allowed for automatic data collection via personal monitoring devices worn by the patient. Using standardized treatment plans and system analysis of patient data, "the system delivers automated feedback consisting of alerts, reminders, and motivational messages in real time and periodically (over three and seven days' period)" (Fico et al., 2016, p. 30). Phamily (n.d.) integrates its chronic care management service into your EHR and provides a "unique texting-based approach to patient engagement" (para. 1). MCG Health offers assessments for people experiencing chronic conditions and high-intensity and low-intensity guidelines for disease management along with patient engagement tools (Miller, 2023). These examples show the types of case management tools being developed for chronic disease management within and outside of the healthcare system.

Communication systems promote interaction among healthcare providers and between providers and patients and are designed to

be Health Insurance Portability and Accountability Act (HIPAA) compliant. Such systems have historically been kept separate from other types of health ISs and from one another. Healthcare professionals overwhelmingly recognize the value of these systems, however, so they are now more commonly integrated into the design of other types of systems as a newly developing standard within the industry. There is no one size fits all for communication systems. According to Mock (2021), "the log-out mechanisms in provider-to-provider systems make them impractical for emergency alerts, while the capabilities of provider-to-patient systems (or vice versa) do not support mass notification" (para. 15). Examples of communication systems include call light systems, wireless telephones, pagers, email, and instant messaging, which have traditionally been forms of communication targeted at clinicians. Other communication systems target patients and their families. Some patients are now able to access their electronic chart from home via an internet connection. They can update their own medical record to inform their physician of changes to their health or personal practices that affect their physical condition. Inpatients in hospital settings also receive communication directly to their room. Patients and their families may, for example, review individualized messages with scheduled tests and procedures for the day and confirm menu choices for their meals. These types of systems may also communicate educational messages, such as smoking cessation advice.

With the introduction of more of these technologies into practice, the value of having communication tools integrated with other types of systems is being widely recognized. Integrating communication systems with clinical applications provides a real-time approach that facilitates interactions among the entire healthcare team and patients and their families to enhance care. These systems improve the flow of communication within an organization and promote an exchange of information to better care for patients. The next generation of communication systems will be integrated with other types of healthcare systems and guaranteed to work together smoothly. The following Research Briefs from 2010, 2014, and 2020 discuss the economic and quality healthcare effect of communication

inefficiencies in U.S. hospitals. As hospitals and physician practices strive to become more **patient centered**, communication technologies will be an integral part of this goal. Many of us have experienced the anxiety of waiting for news about a loved one during a surgical procedure. Newer communication techniques, such as surgical tracking boards that communicate about the process, help to ease these anxieties. Gordon and colleagues (2015) reported high patient and family satisfaction with a HIPAA-compliant surgical instant messaging system to communicate real-time surgical progress with patient-designated recipients. Post–COVID-19 pandemic conditions continue to affect communication styles and challenge healthcare professionals to demand **unified communications (UC)** in health care. Carter (2022) stated that the UC "market will grow at a rate of 18.3% in the healthcare space up to the year of 2026, enabling the sector to provide a better quality of patient care" (para. 2).

What are some other ways that new communication technologies could be harnessed into a UC interface and leveraged to increase patient and family satisfaction with health care in your practice?

RESEARCH BRIEFS

2010

Researchers attempted to quantify the costs of poor communication, termed *communication inefficiencies*, in hospitals. This qualitative study was conducted in seven acute care hospitals of varying sizes via structured interviews with key informants at each facility. The interview questions focused on four broad categories: (1) communication bottlenecks, (2) negative outcomes as a result of those bottlenecks, (3) subjective perceptions of the potential effectiveness of communication improvements on the negative outcomes, and (4) ideas for specific communication improvements. The researchers independently coded the interview data and then compared results to extract themes.

All the interviewees indicated that communication was an issue. Inefficiencies revolved around time spent tracking people down to communicate with them, with various estimates provided: 3 hours per nursing

shift wasted tracking people down, 20% of productive time wasted on communication bottlenecks, and a reported average of five to six telephone calls to locate a physician. Several respondents pointed to costly medical errors that were the direct result of communication issues. Communication lapses also resulted in inefficient use of clinician resources and increased length of stay for patients.

The researchers developed a conceptual model of communication quality with four primary dimensions: (1) efficiency of resource use, (2) effectiveness of resource use, (3) quality of work life, and (4) service quality. They concluded that the total cost of communication inefficiencies in U.S. hospitals is more than $12 billion annually and estimated that a 500-bed hospital could lose as much as $4 million annually because of such problems. They urge the adoption of information technologies to redesign workflow processes and promote better communication. It would be interesting to see this study repeated today to ascertain whether these inefficiencies still exist despite the introduction of newer technologies.

The full article appears in: Agarwal, R., Sands, D., Schneider, J., & Smaltz, D. (2010). Quantifying the economic impact of communication inefficiencies in U.S. hospitals. *Journal of Healthcare Management*, *55*(4), 265–281.

2014

The Ponemon Institute (2014) surveyed more than 400 U.S. healthcare providers about the conventional communication process during three clinical workflows: coordinating emergency response, admitting patients, and transferring patients. There was overwhelming agreement among the participants that significant time was wasted during each workflow basically because of ineffective communications having an "estimated annual economic impact of about $1.75 million per U.S. hospital and more than $11 billion industry-wide" (Ponemon Institute, 2014, para. 4).

2020

Dinsdale et al. (2020) analyzed data from 3,293 referral letters and 2,468 response letters from 68 general practices and 17 hospitals in addition to 6,800 patients' files over a 2-year period.

The authors identified several "areas for improvement at different points in the patient journey in the context of increasing complexity in medicine due to chronic disease and multi-morbidity" (Dinsdale et al., 2020, p. 67). It was interesting to note that there were communication gaps caused by the length of time it took to deliver letters from the hospital to general practitioners. The authors stressed that "it is possible to adopt appropriate evidence-based strategies to improve the quality and timeliness of referral and response

letters. Future research should be aimed at developing robust strategies to addressing communication gaps reported in this study" (Dinsdale et al., 2020, p. 67).

Dinsdale, E., Hannigan, A., O'Connor, R., O'Doherty, J., Glynn, L., Casey, M., Hayes, P., Kelly, D., Cullen, W., & O'Regan, A. (2020). Communication between primary and secondary care: Deficits and danger. *Family Practice*, *37*(1), 63–68. https://doi.org/10.1093/fampra/cmz037

Core Business Systems

Core business systems enhance administrative tasks within healthcare organizations. Unlike **clinical information systems (CISs)**, whose aim is to provide support for direct patient care, these systems support the administrative management of health care within an organization. Core business systems provide the framework for reimbursement, support of best practices, quality control, and resource allocation. There are four common core business systems: (1) admission, discharge, and transfer (ADT) systems; (2) financial systems; (3) acuity systems; and (4) scheduling systems.

Admission, discharge, and transfer (ADT) systems provide the backbone structure for the other types of clinical and business systems and, when automated, provide opportunities for health information exchange leading to care coordination (Michigan Health Information Network, 2019). These systems were among the first to be automated in health care. Admitting, billing, and bed management departments most commonly use ADT systems within the hospital setting. These systems hold key information on which all other systems rely. For example, ADT systems maintain the patient's name; medical record number; visit or account number; and demographic information, such as age, gender, home address, and contact information. Such systems are considered the central source for collecting this type of patient information and communicating it to other types of healthcare ISs. Initially, these systems were primarily in-house management systems, but with the national health IT expansion, ADT systems may communicate important information about patient transitions (i.e., admissions, discharges, and/or emergency room visits) to the primary care physician, insurance company, community case manager, or skilled nursing and rehabilitation facilities. The ADT alert system was designed to improve communication across care providers, improve chronic care patient management, and reduce unnecessary hospital utilization

(Michigan Health Information Network, n.d.; ONC, 2013). The ADT notifications help to determine overutilization and provide the information necessary for healthcare providers to intervene by identifying those patients who repeatedly access the healthcare system. Once identified, the provider can assist these super user, high utilizer, or super-high utilizer patients by affording both clinical and nonclinical options or interventions. The goal is to decrease the amount of overutilization by avoiding or preventing visits to the emergency room as well as readmissions to the hospital (Gilbert et al., 2018; Maruster et al., 2021; Tsai et al., 2018).

HealthShare Exchange (n.d.) in Philadelphia collects ADT data from 39 hospitals and makes it possible to track patients receiving services from multiple providers, thus promoting coordinated care and care efficiencies. Even in long-term care, "[c]loud-based ADT message systems can now be synched with handheld devices, giving caregivers access to a resident's medical data on the go. There has also been considerable improvement in data entry accuracy as well as improved data organization" (Wong, 2022, para. 5).

Financial systems manage the expenses and revenue for providing health care. The finance, auditing, and accounting departments within an organization most commonly use financial systems. These systems determine the direction for maintenance and growth for a given facility. They often interface to share information with materials management, staffing, and billing systems to balance the financial effect of these resources within an organization. Financial systems report fiscal outcomes, which can then be tracked and related to the organizational goals of an institution. These systems are key components in the decision-making process as healthcare institutions prepare their fiscal budgets. They often play a pivotal role in determining the strategic direction for an organization.

Acuity systems monitor the range of patient types within a healthcare organization using specific indicators. They track these indicators based on the current patient population within a facility. By monitoring the patient's acuity, these systems provide feedback about how intensive the care requirement is for an individual patient

or for a group of patients. Identifying and classifying a patient's acuity can promote better organizational management of the expenses and resources necessary to provide quality care. Information about a patient's acuity also provides important insights into staffing for safe care delivery. Acuity systems help predict the ability and capacity of an organization to care for its current population. They also forecast future trends to allow an organization to successfully strategize on how to meet upcoming market demands. Trepanier et al. (2017) reported on the implementation of a value-based nurse staffing model using a data-driven, interoperable acuity-based staffing (ABS) system. "Sophisticated ABS technology offers many new and exciting options that are significantly more accurate and less burdensome than the traditional staffing process. Such systems not only improve value to patients by supporting the achievement of consistently better outcomes across the healthcare system, but they also provide reliable data to inform a variety of day-to-day and long-term planning and management tasks" (p. 188). Handzel (2021) described the nurse and non-nurse support staffing changes that were done in response to the COVID-19 pandemic. To increase responsiveness, several changes were made, such as creating a 1:4 ratio of nurses to patients and increasing the use of non-nurse support personnel. Also, "[a]lternative med/surg suites were prepared in the radiology care unit, CCL [cardiac catheterization lab], and two GI [gastrointestinal] procedural centers" (Handzel, 2021, para. 9).

Scheduling systems coordinate staff, services, equipment, and allocation of patient beds. They are frequently integrated with the other types of core business systems. By closely monitoring staff and physical resources, these systems provide data to the financial systems. For example, resource-scheduling systems may provide information about operating room use or availability of intensive care unit beds and regular nursing unit beds. These systems also provide great assistance to financial systems when they are used to track medical equipment within a facility. Procedures and care are planned when the tools and resources are available. Scheduling systems help

to track resources within a facility while managing the frequency and distribution of those resources.

Increasingly, hospital systems are moving to enterprise resource planning (ERP) software that integrates many of the core business functions into one package, thus providing seamless access to data that can be used for planning, mandatory reporting, and overall strategic management purposes. “Implementing an ERP system can provide significant benefits for healthcare providers, not only in the promotion of proficient performance and functionality, but also in positioning organizations to respond to a quickly evolving industry” (DeLeon, n.d., para. 12).

Order Entry Systems

Order entry systems are one of the most important systems in use today. They automate the way that orders have traditionally been initiated for patients; that is, clinicians place orders using these systems instead of creating traditional handwritten transcriptions onto paper. Order entry systems provide major safeguards by ensuring that physician orders are legible and complete, thereby providing a level of patient safety that was historically missing with paper-based orders. **Computerized physician (or provider) order entry (CPOE) systems** provide decision support and automated alert functionality that was unavailable with paper-based orders.

In the seminal report by the Institute of Medicine (2000), *To Err Is Human: Building a Safer Health System*, it was estimated that medical errors cost the United States approximately $37.6 billion each year; nearly $17 billion of those costs are associated with preventable errors. Consequently, the federal Agency for Healthcare Research and Quality Patient Safety Network (2019) continued to recommend eliminating reliance on handwriting for ordering medications and advocated instead for CPOE paired with clinical decision support. Because of the global concern for patient safety as a result of incorrect and misinterpreted orders, healthcare organizations are incorporating order entry systems into their operations as a standard tool for practice. Such systems allow for clear and legible orders, thereby promoting patient safety and streamlining care.

Patient Care Support Systems

Most specialty disciplines within health care have an associated **patient care information system**. These patient-centered systems focus on collecting data and disseminating information related to direct care. Several of these systems have become mainstream types of systems used in health care. The four systems most commonly encountered in health care are (1) clinical documentation systems, (2) pharmacy information systems, (3) laboratory information systems, and (4) radiology information systems.

Clinical documentation systems, also known as clinical information systems (CISs), are the most commonly used type of **patient care support system** within healthcare organizations. CISs are designed to collect patient data in real time. They enhance care by putting data at the clinician's fingertips and enabling decision-making where it needs to occur, which is at the bedside. For that reason, these systems often are easily accessible at the point of care for caregivers interacting with the patient. CISs are patient centered, meaning they contain the observations, interventions, and outcomes noted by the care team. Team members enter information, such as the plan of care, hemodynamic data, laboratory results, clinical notes, allergies, and medications. All members of the treatment team use CISs; for example, pharmacists, allied health workers, nurses, physicians, support staff, and many others access patients' clinical records using these systems. Accuracy and thoroughness of clinical documentation are increasingly emphasized because the quality of documentation is now tied to reimbursement. Because of this, larger health systems began employing **clinical documentation improvement (CDI)** specialists, who review electronic records for gaps and inaccuracies in charting (Miliard, 2017). These specialists generally have both clinical and coding backgrounds so that they can review the medical records or

documentation for missing data and information in relation to the disease process, diagnostics, and coding (AAPC, 2023).

Frequently, these clinical documentation systems are also referred to as the electronic patient record, or **electronic health record (EHR)**.

Pharmacy information systems also have become mainstream patient care support systems. They typically allow pharmacists to order, manage, and dispense medications for a facility. They also commonly incorporate information regarding allergies and height and weight to ensure effective medication management. Pharmacy information systems streamline the order entry, dispensing, verification, and authorization process for medication administration. They often interface with clinical documentation and order entry systems so that clinicians can order and document the administration of medications and prescriptions to patients while having the benefits of decision-support alerting and interaction checking. Technologies emerging in pharmacy information systems include automated dispensing cabinets, CPOE, smart pumps, bar-coded medication administration (BCMA) systems, bar-coded unit dose packaging systems, and temperature monitoring systems. Halvorsen (2018) was correct in suggesting that the use of robotics was a trend worth watching. MarketWatch (2023) stated that the "global robotic prescription dispensing systems market is anticipated to rise at a considerable rate during the forecast period, between 2022 and 2030" (para. 1).

Laboratory information systems were perhaps some of the first CISs ever used in health care. Because of their long history of use within medicine, laboratory systems have been models for the design and implementation of other types of patient care support systems. Laboratory information systems report on blood, body fluid, and tissue samples along with biological specimens collected at the bedside and received in a central laboratory. They provide clinicians with reference ranges for tests indicating high, low, or normal values to make care decisions. Often, the laboratory system provides result information in the EHR and directs clinicians toward the next course of action within a treatment regimen. As older legacy systems are

phased out, new laboratory information systems are designed to be fully interoperable with other health ISs, thus reducing turnaround times for specimen collection, transport, and analysis and providing opportunities for data analysis beyond basic results reporting (Muin, 2017). Interoperability of the laboratory information system is critical in the "move to interoperable healthcare systems because of the tremendous amount of data it manages and the value of that data in making patient care decisions" (Futrell, 2021, para. 1). The final type of patient care support system commonly found within health care is the **radiology information system (RIS)** used in radiology departments. These systems schedule, provide results, and store information related to diagnostic radiology procedures. One feature found in most radiology systems is a **picture archiving and communication system (PACS)**. The PACS may be a stand-alone system, which is kept separate from the main radiology system, or it can be integrated with the RIS and CIS. These systems collect, store, and distribute medical images, such as computed tomography scans, magnetic resonance images, and X-rays. PACS replaces traditional hard copy films with digital media that are easy to store, retrieve, and present to clinicians. The benefit of RIS and PACS is their ability to assist in diagnosing and storing vital patient care support data. Imaging studies can be available in minutes as opposed to 2 to 6 hours for images in a film-based system. The digital workstations provide enhanced imaging capabilities and on-screen measurement tools to improve diagnostic accuracy. Finally, the archive system stores images in a database that is readily accessible so that images can be easily retrieved and compared to subsequent testing or shared instantly with consultants. Advances in RIS/PACS systems include the use of machine learning techniques to analyze data and create decision-support mechanisms. Brink et al. (2017) suggested that "[t]he use of machine learning promises better decision support for medical imaging, improved quantitative imaging, improved computer-assisted diagnoses, improved computer-assisted radiology for structured report generation, precision in diagnosis, and real-time correlation with other medical data" (p. 3649). However, Rockall (2019) provided a caution about

the use of artificial intelligence (AI) and machine learning in radiology: "The key is to ensure that AI is used to address important unmet clinical needs, whether in relation to triage and diagnostic tools, improved workflow or sustainability of healthcare. Applications of AI must primarily serve patient needs, not just what's interesting or feasible" (p. 1). AI will greatly enhance and augment the field of radiology but not replace radiologists as once thought.

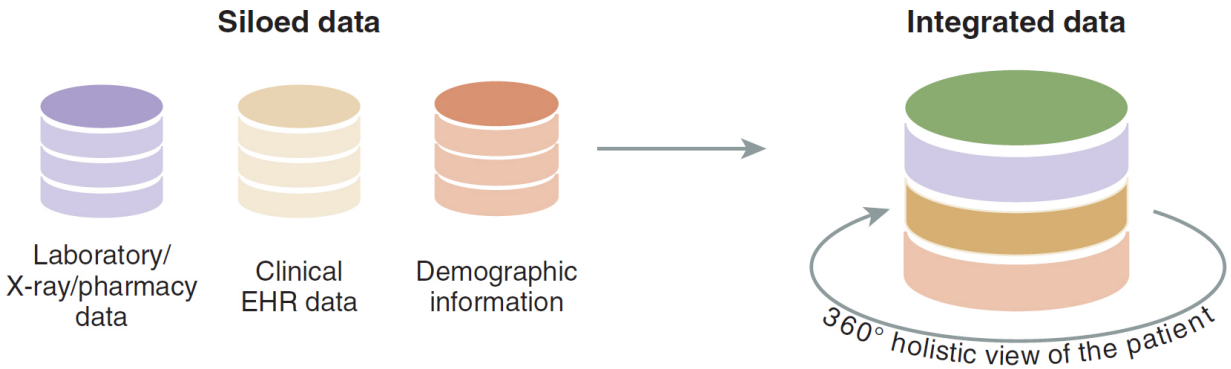
The mobility of patients both geographically and within a single healthcare delivery system challenges ISs because data must be captured wherever and whenever the patient receives care. In the past, **managed care information systems** were implemented to address these issues. Consequently, data can be obtained at any and all of the areas where a patient interacts with the healthcare system. Patient-tracking mechanisms continue to be honed, but the financial impact of health care also has changed these systems to some extent. The ISs currently in use enable nurses and physicians to make clinical decisions while being mindful of their financial ramifications. In the future, vast improvements in ISs and systems that support health information exchange are likely to continue to emerge.

One such trend is the incentive to develop accountable care organizations (ACOs), which are encouraged by the Patient Protection and Affordable Care Act of 2010. According to the Centers for Medicare and Medicaid Services (2020), "Accountable Care Organizations (ACOs) are groups of doctors, hospitals, and other health care providers, who come together voluntarily to give coordinated high quality care to their Medicare patients. The goal of coordinated care is to ensure that patients, especially the chronically ill, get the right care at the right time, while avoiding unnecessary duplication of services and preventing medical errors" (para. 1–2). Members of an ACO share data and information to better coordinate care and share in any healthcare cost savings generated when the coordination of care reduces unnecessary and duplicated costs.

Aggregating Patient and Organizational Data

Many healthcare organizations now aggregate data in a data warehouse for the purpose of mining the data to discover new relationships and build organizational knowledge. Proper access to the data and big data analyses are critical to improving patient outcomes and healthcare processes. Data storage strategies can not only impact how data is made available to users and applications but also the success of any data analysis.

In addition to the access and storage challenges, "the information collected and generated by hospitals is managed and stored following the set standards" (Kholodenko, 2022, para. 56): HIPAA, electronic protected health information (EPHI), and Health Information Technology for Economic and Clinical Health (HITECH) Act. When disparate ISs within an organization are unable to interface with any other ISs (either within or outside of the organization), the result is poor communication, billing errors, and issues with continuity of care. By developing a single comprehensive database, healthcare systems are able to facilitate interprofessional communications yet maintain compliance with privacy regulations. **Figure 10-1** depicts moving from siloed to integrated data.



Data from: SmartData Collective. (2015, October 5). *Two critical obstacles facing retailers for data driven marketing*. www.smartdatacollective.com/two-critical-obstacles-facing-retailers-data-driven-marketing

Figure 10-1 Moving From Data Silos to Integrated Data

Description

Based on the size of the organization, data **triage** and **tiering** might be necessary. These decision-making processes related to data storage are based on predictions regarding how quickly data might need to be accessed. For example, consider the case of Intermountain, a chain of 22 hospitals in Salt Lake City. With 4.7 petabytes of data under its management, cloud storage becomes cost prohibitive. The network estimates the size of the hospital chain's data will grow by 25% to 30% each year until it reaches 15 petabytes 5 years from now (DeGaspari, 2013, para. 1).

With such massive data needs, it was imperative that Intermountain find ways to cut costs and streamline efficiency. One way was through data tiering, which is the creation of data storage tiers that can be accessed when necessary at the appropriate speeds. Tiering can be done manually through triaging but is typically accomplished through auto-tiering, which automatically stores data according to availability needs. Therefore, auto-tiering determines the media storage necessary to meet the data needs and can be a cost saver by storing data on lower-cost media when appropriate.

The most basic element of a database system is the data. Data refer to raw facts that can comprise unorganized text, graphics, sound, or video. Information is data that have been processed, meaning the data have been organized in a way that people find meaningful and useful. Even useful information can be lost if one is mired in unorganized information. Computers can come to the rescue by helping to create order out of chaos. Computer science and information science are designed to help cut down the amount of information to a more manageable size and organize it so that users can cope with it more efficiently through the use of databases and database program technology. Learning about basic databases

and database management programs is paramount so that users can apply data and information management principles in health care.

A **database** is a structured or organized collection of data that is typically the main component of an IS. Databases and database management software allow the user to input, sort, arrange, structure, organize, and store data and turn those data into useful information. An individual can set up a personal database to organize recipes, music, names and addresses, notes, bills, and other data. In health care, databases and ISs make key information available to healthcare providers and ancillary personnel to promote the provision of quality patient care. **Box 10-1** provides a detailed description of a database.

BOX 10-1 OVERVIEW OF DATABASE CONSTRUCTION

Databases consist of **fields**, or **columns**, and records, or **rows**. Within each record, one of the fields is identified as the **primary key**, or **key field**. This primary key contains a code, name, number, or other information that acts as a unique identifier for that record. In the healthcare system, for example, a patient is assigned a patient number, or ID, that is unique for that patient. As you compile related records, you create data files, or tables. A **data file** is a collection of related records. Therefore, databases consist of one or more related data files or tables.

An **entity** represents a table, and each field within the table becomes an **attribute** of that entity. The database developer must critically think about the attributes for each entity. For example, the entity *disease* might have the attributes of *chronic disease*, *acute disease*, or *communicable disease*. The name of the entity, *disease*, implies that the entity is about diseases. The fields, or attributes, are *chronic*, *acute*, or *communicable*.

The **entity relationship diagram** specifies the relationship among the entities in the database. Sometimes the implied relationships are readily apparent based on the entities' definitions; however, all relationships should be specified as to how they relate to one another. Typically, three relationships are possible: (1) one to one, (2) one to many, and (3) many to many. A one-to-one relationship exists between the entities of the table about a patient and the table about the patient's birth. A one-to-many relationship could exist when one entity is repeatedly used by another entity. Such a one-to-many

relationship could then be a table query for age that could be used numerous times for one patient entity. The many-to-many relationship reflects entities that are used repeatedly by other entities. This is easily explained by the entities of patient and nurse. The patient could have several nurses caring for them, and the nurse could have many patients assigned to them (see **Figure 10-2**).

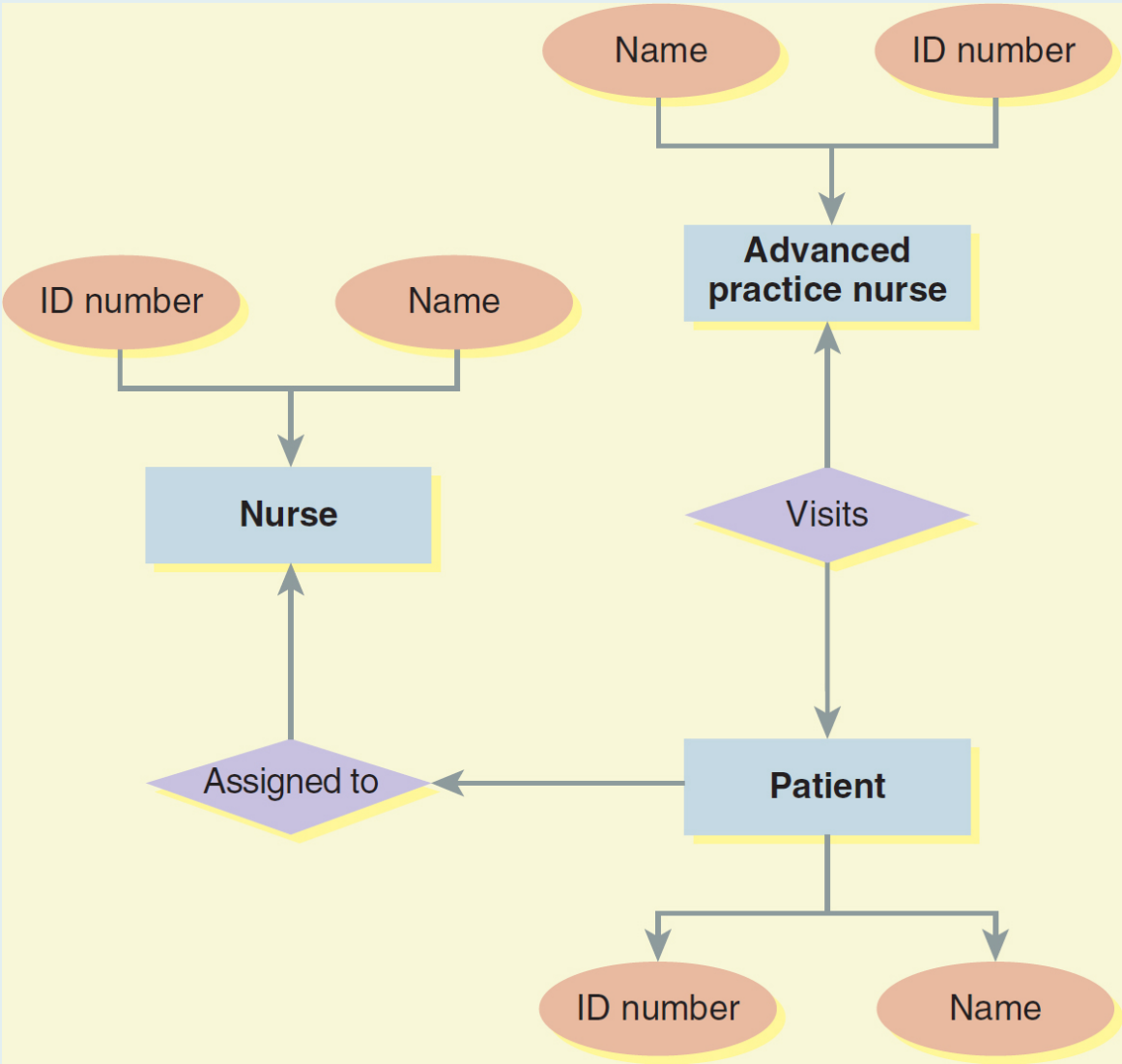


Figure 10-2 Example of an Entity Relationship Diagram

Description

The relational model is a database model that describes data in which all data elements are placed in relation in two-dimensional tables; the relations, or tables, are analogous to files. A **relational database management**

system (RDMS) is a system that manages data using this kind of relational model. A relational database could link a patient's table to a treatment table (e.g., by a common field, such as the patient ID number). To keep track of the tables that constitute a database, the database management system uses software called a data dictionary. The **data dictionary** contains a listing of the tables and their details, including field names, validation settings, and data types. The data type refers to the type of information, such as a name, a date, or a time.

The **database management system** is an important program because, before it was available, many health systems and businesses had dozens of database files with incompatible formats. Because patient data come from a variety of sources, these separated, isolated data files required duplicate entry of the same information, thereby increasing the risk of data entry error. The design of the relational databases eliminates data duplication. Some examples of popular database management system software include Microsoft's Access and Visual FoxPro, Oracle's Oracle Database 21c, and IBM's Db2.

On a large scale, a **data warehouse** is an extremely large database, or **repository**, that stores all of an organization's or institution's data and makes these data available for **data mining**. The data warehouse can combine an institution's many databases to provide management personnel with flexible access to the data. On a smaller scale, a **data mart** represents a large database in which the data used by one of the units or a division of a healthcare system are stored and maintained. For example, a university hospital system might store clinical information from its many affiliate hospitals in a data warehouse, and each separate hospital might have a data mart housing its data.

There are many ways to access and retrieve information in databases. Searching information in databases can be done through the use of a query, as is used in Microsoft's Access database. A **query** asks questions of the database to retrieve specific data and information. **Box 10-2** provides a detailed description of the **Structured Query Language (SQL)**.

BOX 10-2 STRUCTURED QUERY LANGUAGE (SQL)

SQL was originally called SEQUEL, or Structured English Query Language. SQL, still pronounced "sequel," now stands for Structured Query Language; it is a database querying language, rather than a programming language, and a standard language for accessing and manipulating databases. SQL is "used with relational databases; it allows users to define the structure and organization of stored data, verify and maintain data integrity, control access to the data, and define relationships among the stored data items" (Blink, 2016, para. 8). SQL simplifies the process of retrieving information from a database in a functional or usable form while facilitating the reorganization of data within the databases.

The RDMS is the foundation for SQL. Data in an RDMS are stored in tables. A **table** is a collection of related data that consists of columns, which are also referred to as fields, and rows, which are also referred to as records, or tuples (Peterson, 2023). Databases can have many tables, and each table is identified by a name. The consistent formatting and organization of data in an RDMS allows a user to easily enter, view, and manipulate data (see the following Database Example: School of Nursing Faculty).

SQL statements handle most of the actions users need to perform on a database. SQL is an **International Organization for Standardization (ISO)** and **American National Standards Institute (ANSI)** standard (Indiana University, 2021). To remain compliant with the ISO and ANSI standards, SQL must handle or support the most typical major commands such as SELECT, UPDATE, DELETE, INSERT, and WHERE (Prateek, 2023). The SELECT command allows extraction of data from a database, UPDATE updates the data, DELETE deletes the data, and INSERT inserts new data. WHERE is used to specify selection criteria, thereby restricting the results of the SQL query. Thus, SQL allows the creation of databases and their manipulation by storing, retrieving, updating, and deleting data. Coursera (2023) described SQL as a powerful method of storing and being able to interact with data. SQL supports high-quality data analysis due to its flexibility and power.

Database Example: School of Nursing Faculty						
Table Named "Faculty"						
P_ID	Last Name	First Name	Department Affiliation	Office Phone Number	Office Location	UserID
1	Eggleers	Renee	Informatics	444-111-1104	104A	Eggleersr100
2	Feistyz	Judi	Gerontology	444-111-2202	202b	Feistyzj562
3	Martinez	Bethann	Neurology	444-111-3336	336C	Martinezb789
4	Smythe	Ralph	Informatics	444-111-1110	110A	Smyther355

Description

The database example provided here reflects the faculty listing for a school of nursing. The table that contains the data is identified by the name "Faculty." The faculty members are categorized by the following fields (columns): Last Name, First Name, Department Affiliation, Office Phone Number, Office Location, and UserID. Each faculty member's information is a record (**tuple**, or row).

Using the SQL command SELECT, all the records in the "Faculty" table can be selected:

- SELECT * FROM Faculty

This command would SELECT all (*) of the records FROM the table known as FACULTY. The asterisk (*) is used to select all the columns.

Data mining software sorts through data to discover patterns and ascertain relationships. This software discovers previously unidentified relationships among the data in a database by conducting an exploratory analysis looking for hidden patterns in data. Using such software, the user searches for previously undiscovered patterns by analyzing the data stored in a data warehouse. ***Drill down*** is a term that means the user can view data warehouse information by drilling down to lower levels of the database to focus on information that is pertinent to their needs at the moment.

As users move through databases within the healthcare system, they can access anything from enterprise-wide data warehouses to data marts. For example, an infection control nurse might notice a

pattern of methicillin-resistant *Staphylococcus aureus* infections in the local data mart (a single hospital within a larger system). The nurse might want to find out whether the outbreak is local (data mart) or more widespread in the system (data warehouse). The nurse might also query the database to determine whether certain patient attributes (e.g., age or medical diagnosis) are associated with the incidence of infection.

These kinds of data mining capabilities are also quite useful for healthcare practitioners who wish to conduct clinical research studies. For example, one might query a database to tease out attributes (i.e., patient characteristics) associated with asthma-related hospitalizations.

In 2013, Mishra et al. were the first to report on a new set of challenges and opportunities for managing data and data mining and establishing data analysis algorithms in the cloud. At the time, this development was game changing for organizations. The world as we knew it was changing. Clouds are leading us to develop revolutionary data mining technologies because the organization can take advantage of the sophisticated software and processing methodology available from the cloud provider without having to invest in them individually. Hein (2019) discussed the benefits and risks of cloud computing in health care. Benefits include data storage capacity, scalability (i.e., matching service demands), ease of collaboration, and access to AI and machine learning processing. Risks include training needed for proper implementation, security vulnerabilities, HIPAA compliance, and availability and control of the data.

Blockchain technology is showing great promise in solving some of the issues associated with traditional databases and cloud computing. Blockchain is widely described as a distributed ledger technology. "A blockchain is, in the simplest of terms, a time-stamped series of immutable record of data that is managed by a cluster of computers not owned by any single entity. Each of these blocks of data (i.e., block) is secured and bound to each other using cryptographic principles (i.e., chain)" (Chadha, 2020, para. 7). Every transaction is recorded in the blockchain and trackable, and

authorized users will have immediate access to records updated in real time. However, each new change is recorded in a new block so that authorized users can retrace the steps in the information trail to understand changes as they occurred. These private chains are also referred to as permissioned chains, and they offer a high level of security. Potential uses of blockchain technology in health care include managing patient records with a hash ID unique identifier to allow more accurate matching of records from different providers, seamless sharing of records and health data as the patient permits, incentivizing healthy behaviors, managing the pharmacy supply chain, curtailing insurance fraud, and conducting research and clinical trials using secure and trusted data (Chadha, 2020). Block chain is currently being used in health care for "everything from securing patient data to managing the pharmaceutical supply chain" (Daley, 2023, para. 1).

Department Collaboration and Exchange of Knowledge and Information

The implementation of systems within health care is the responsibility of many people and departments. All systems require a partnership of collaboration and knowledge sharing to implement and maintain successful standards of care. **Collaboration** is the sharing of ideas and experiences for the purposes of mutual understanding and learning. **Knowledge exchange** is the product of collaboration when sharing an understanding of information promotes learning from past experiences to make better future decisions.

Depending on the type of project, collaboration may occur at several levels within an organization. At an administrative level, collaboration among key stakeholders is critical to the success of any project. Stakeholders have the most responsibility for completing the project. They have the greatest influence on the overall design of the system because, ultimately, they are the people who are most impacted by a system implementation. Together with the organizational executive team, stakeholders collaborate on the overall budget and time frame for a system implementation.

Collaboration may also occur among the various departments affected by the system. These groups frequently include representatives from IT, clinical specialty areas, support services, and software vendors. Once a team is assembled, it defines the objectives and goals of the system. The team members work strategically to align their goals with the goals of the organization where the system is to be used. The focus for these groups is on planning, resource management, transitioning, and ongoing support of the system. Their collaboration determines the way in which the project is managed—the deliverables for the project, the individuals held accountable for the project, the time frame for the project, and

the opportunities for process improvement using the system—and the means by which resources are allocated to support the system.

From collaboration comes the exchange of information and ideas through knowledge sharing. Specialists exchange knowledge within their respective areas of expertise to ensure that the system works for an entire organization. From one another, they learn the requirements that make the system successful. This exchange of ideas is what makes healthcare ISs so valuable. A multidisciplinary approach ensures that systems work in the complex environment of healthcare organizations, which have diverse and complex patient populations.

Summary

The integration of technology within healthcare organizations offers limitless possibilities. As new types of systems emerge, clinicians will become smarter and more adept at incorporating these tools into their daily practice. Success will be achieved when health care incorporates technology systems in a way that they are not viewed as separate tools to support healthcare practices but rather as necessary instruments to provide healthcare. Patients, too, will become savvier at using healthcare ISs as a means of communicating and managing their personal and preventive care. In the future, these two mindsets will become expectations for health care and not simply a high-tech benefit, as they are often viewed today.

Ultimately, it is not the type of systems adopted that is important but rather the method in which they are put into practice. In an ideal world, robust and transparent information technologies will support clinical and administrative functions and promote safe, high-quality, and cost-effective care.

THOUGHT-PROVOKING QUESTIONS

1. Which type of technology exists today that could be converted into new types of ISs to be used in health care?
2. How could collaboration and knowledge sharing at a single organization be used to help individuals preparing for IT at a different facility?
3. Explore the administrative ISs and their applications in your healthcare organization.
   a. What are the main systems used?
   b. How are data shared among systems?
   c. What examples of functional, structural, and semantic interoperability can you identify?
4. Reflect on the communication tools available in a clinical setting. How do UC systems affect and address the inefficiencies in communication that

currently exist? What else needs to be done to eliminate communication inefficiency and gaps?

5. Assess all the reasons, in detail, as to why CDI is necessary. How does it address missing, incomplete, and inaccurate records, including coding errors? Could AI be employed to complete this task? Explain, in detail, why or why not.
6. Why are ADT systems critical to the improvement of communication across care providers? How can ADT improve chronic care patient management and reduce unnecessary hospital utilization?

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CHAPTER 11

The Human–Technology Interface

OBJECTIVES

1. Describe the human–technology interface.
2. Explore human–technology interface problems.
3. Analyze the human–technology interface problems you have identified in your personal and professional lives.
4. Reflect on the future of the human–technology interface.

KEY TERMS

- application programming interface (API)
- cognitive task analysis
- cognitive walkthrough
- cognitive work analysis (CWA)
- earcon
- ecological interface design (EID)
- ergonomics
- field study
- gulf of evaluation
- gulf of execution
- heuristic evaluation
- human–computer interaction
- human factor
- human–technology interaction

- human–technology interface
- *mapping*
- natural language processing (NLP)
- near field communication (NFC)
- Near Field Communication Interface and Protocol (NFCIP-1)
- near field communication-enabled medication administration (NFCMA)
- situational awareness
- task analysis
- *usability*
- user experience (UX)
- user interface (UI)
- wearable technology
- workaround

Introduction

One of the authors of this chapter stayed in a new hotel on the outskirts of London. When she entered her room, she encountered three wall-mounted light switches in a row with no indication of which lights they operated. In fact, the mapping of switches to lights was so peculiar that she was more often than not surprised by the light that came on when she pressed a particular switch. One might conclude that the author had a serious problem, but she prefers to attribute her difficulty to poor design. When these kinds of technology design issues surface in health care, they are more than just an annoyance. Poorly designed technology can lead to errors, lower productivity, or even removing the system (Alexander & Staggers, 2009; Benjamins, 2021; Hannah, 2023). Unfortunately, as more and more kinds of increasingly complex health information technology applications are integrated, the problem becomes even worse (Johnson, 2006; Lau et al., 2019). However, nurses are very creative, and if it is at all possible, they will design **workarounds** that allow them to circumvent troublesome technology. However, workarounds are only a temporary solution.

In his classic book, *The Psychology of Everyday Things*, Norman (1988) argued that life would be a lot simpler if people who built the things that others encounter (such as light switches) paid more attention to how they would be used. At least one everyday thing meets Norman's criteria for good design: the scythe. Even people who have never encountered one will pick up a scythe in the manner needed to use it because the design makes only one way feasible. The scythe's design fits perfectly with its intended use and a human user. Would it not be great if all technology were so well fit to human use? In fact, this is not such a far-fetched idea. Scientists and engineers are making excellent strides in understanding human–technology interface problems and proposing solutions to them.

As you read through this chapter, reflect on the everyday items you use. What makes them easy or difficult to use? Is it evident that

the developer thought about how they would be used to facilitate their design and function? Next, turn your attention to the technologies you use. Is it evident that the developer thought about how the technology would be used to facilitate its design and function? Think about your smartphone. How easy is it to hold your smartphone? Is it intuitive and easy to access and use? What improvements would you make? Does the electronic health record (EHR) system you use support your workflow and patient needs? Do you use workarounds to avoid items that you feel should not be there or are not needed at the time of entry? Do you think that the developer understood you, as the user, or did not realize how the technology tool would be used? By the end of this chapter, you should be able to critically examine the human–technology interfaces currently available in health care and describe models, strategies, and exemplars for improving interfaces during the analysis, design, and evaluation phases of the development life cycle.

The Human–Technology Interface

What is the **human–technology interface**? Broadly speaking, any time a human uses technology, some type of hardware or software enables and supports the interaction. It is this hardware and software that define the interface and how the user will interact with it, the **user interface (UI)**. The **user experience (UX)** is the user's experience from interacting with an object, product, or service. It has been connected to the term ***usability*** and refers to the design of products and services with the user in mind in order to meet the user's needs. There are bad designs and good designs. We have all encountered things that we felt should have been designed better. The array of light switches described previously was actually an interface (although not a great one) between the lighting technology in the room and the human user.

In today's healthcare settings, one encounters a wide variety of human–technology interfaces. Those who work in hospitals may use bar-coded identification cards to log in their arrival time to a human resources management system. Using the same cards, they might log in to their patients' EHRs, access their patients' drugs from a drug administration system, and even administer the drugs using bar-coding technology. Other examples of human–technology interfaces one might encounter include a defibrillator, a patient-controlled analgesia (PCA) pump, any number of physiological monitoring systems, electronic thermometers, and telephones and pagers. Rice and Tahir (2014) examined research that stressed the essence of human–technology interfacing, the **human factor**. They stated that

> *recent studies have found that rapid implementation of new medical technology—electronic health records, patient monitoring devices, surgical robots and other tools—can lead to adverse patient events when it is not thoughtfully integrated into workflow. The right processes require understanding the devices and the users. Testing in controlled environments often does not adequately consider the "human factor," or*

how people interact with technology in high-pressure, real-life situations. (p. 12)

The human interfaces for each of these technologies are different and can even differ among different brands or versions of the same device. For example, to enter data into an EHR, one might use a keyboard, a light pen, a touch screen, or their voice. Healthcare technologies may present information via computer screen, printer, or smartphone. Patient data might be displayed in the form of text, images (e.g., the results of a brain scan), or sound (an echocardiogram); in addition, the information may be presented differently, based on roles and preferences. Dumon's (2017) statement is still timely: "Technology does not determine human action; human action shapes technology. As we push forward into this age of the marriage of data and technology, we must apply the basic principle that technology needs to serve humanity, first and last" (para. 9).

Some human–technology interfaces mimic face-to-face human encounters. For example, faculty members are increasingly using videoconferencing technology to communicate with their students. Similarly, telehealth allows nurses to use telecommunication and videoconferencing software to communicate more effectively and frequently with patients at home by using the technology to monitor patients' vital signs, supervise their wound care, or demonstrate a procedure. To provide comprehensive, quality healthcare interventions, we must fully leverage these tools, take all human factors into account, and make sure they are included in the healthcare provider's clinical workflow. Telehealth technology has fostered other virtual interfaces, such as system-wide intensive care units in which intensivists and specially trained nurses monitor critically ill patients in intensive care units, some of whom may be in rural locations. Sometimes telehealth interfaces allow patients to interact with a virtual clinician (a computer program such as an artificial intelligence [AI] agent or robot) that asks questions, provides social support, and tailors education to identify patient needs based on the answers to screening questions. These human–

technology interfaces have been remarkably successful; sometimes patients even prefer them to live clinicians.

Human–technology interfaces may present information using text, numbers, images, icons, or sound. Auditory, visual, or tactile alarms may alert users to important information. Users may interact with (or control) the technology via keyboards, digital pens, voice activation, or touch.

A small but growing number of clinical and educational interfaces rely heavily on tactile input. For example, many students learn to access an intravenous site using virtual technology. Other, more sophisticated virtual reality applications help physicians learn to do endoscopies or practice complex surgical procedures in a safe environment. Still others allow drug researchers to design new medications by combining virtual molecules (here, the tactile response is quite different for molecules that can be joined from those that cannot). In each of these training environments, accurately depicting tactile sensations is critical. For example, feeling the kind and amount of pressure required to penetrate the desired tissues, but not others, is essential to a realistic and effective learning experience.

The growing use of large databases for research has led to the design of novel human–technology interfaces that help researchers visualize and understand patterns in the data that generate new knowledge or lead to new questions. Many of these interfaces now incorporate multidimensional visualizations in addition to scatter plots, histograms, or cluster representations (Matange et al., n.d.; Vincent et al., 2010). Some designers, such as Quinn (the founder of the Design Rhythmics Sonification Research Laboratory at the University of New Hampshire) and Meeker (2001), began using variations in sound to help researchers hear the patterns in large data sets. In Quinn and Meeker's climate symphony, a variety of musical instruments, tones, pitches, and phrases are mapped onto variables, such as the amounts and relative concentrations of minerals, to help researchers detect patterns in ice core data covering more than 110,000 years. Climate patterns take centuries to emerge and can be difficult to detect. The music allows the entire

110,000 years to be condensed into just a few minutes, making detection of patterns and changes much easier. The ability to quickly model, analyze, assess, synthesize, and discover patterns in large data sets is critical to the future of health care. As the previous examples demonstrated, there are evolving effective ways to model complex healthcare data, visualizing impactful data, and uncovering patterns (Agency for Healthcare Research and Quality, 2019; Kaul, 2020). Healthcare data visualization is flourishing with the increased awareness of the power afforded from the graphical representation of healthcare data. "Data visualization in the healthcare industry is the representation of complex medical stats in a digestible graphical format. It allows users to easily obtain qualitative insights, changes, patterns, and trends while drawing valuable conclusions . . . even without developed math skills (Khristich, 2023, para. 5).



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The human–technology interface is ubiquitous in health care and takes many forms. A look at the quality of these interfaces follows. Be warned, though. It is not always a pretty picture.



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The Human–Technology Interface Problem

In *The Human Factor*, Vicente (2004) cited the many safety problems in health care identified by the Institute of Medicine's (2000) seminal report, *To Err Is Human: Building a Safer Health System*, and noted how the technology (defined broadly) used often does not fit well with human characteristics. As a case in point, Vicente described his own studies of nurses' PCA pump errors. Nurses made the errors in large part because of the complexity of the user interface, which required as many as 27 steps to program the device. Vicente and his colleagues developed a PCA in which programming required no more than 12 steps. Nurses who used it in laboratory experiments made fewer errors, programmed drug delivery faster, and reported lower cognitive workloads compared to using the commercial device. Further evidence that human–technology interfaces do not work as well as they might is evident in the following events.

Doyle (2005) reported that when a bar-coding medication system interfered with nurses' workflow, they devised workarounds, such as removing the armband from the patient and attaching it to the bed because the bar-code reader failed to interpret barcodes when the bracelet curved tightly around a small arm. Koppel et al. (2005) reported that a widely used computerized physician order entry (CPOE) system meant to decrease medication errors actually facilitated 22 types of errors because the information needed to order medications was fragmented across as many as 20 screens, available medication dosages differed from those the physicians expected, and allergy alerts were triggered only after an order was written.

Han et al. (2005) reported increased mortality among children admitted to Children's Hospital in Pittsburgh after CPOE implementation. Three reasons were cited for this unexpected outcome. First, CPOE changed the workflow in the emergency room. Before CPOE, orders were written for critical time-sensitive

treatment based on radio communication with the incoming transport team before the child arrived. After CPOE implementation, orders could not be written until the patient arrived and was registered in the system (a policy that was later changed). Second, entering an order required as many as 10 clicks and took as long as 2 minutes; moreover, computer screens sometimes froze or response time was slow. Third, when the team changed its workflow to accommodate CPOE, face-to-face contact among team members diminished. Despite the problems with study methods identified by some of the informatics community, there certainly were serious human–technology interface problems.

In 2005, a *Washington Post* article reported that Cedars-Sinai Medical Center in Los Angeles had shut down a $34 million system after 3 months because of the medical staff's rebellion. Reasons for the rebellion included the additional time it took to complete the structured information forms, failure of the system to recognize misspellings (as nurses had previously done), and intrusive and interruptive automated alerts (Connolly, 2005). Even though physicians actually responded appropriately to the alerts, modifying or canceling 35% of the orders that triggered them, designers had not found the right balance of helpful-to-interruptive alerts. The system simply did not fit the clinicians' workflow.

Such unintended consequences (Ash et al., 2004) or unpredictable outcomes (Aarts et al., 2004) of healthcare information systems may be attributed in part to a flawed implementation process, but there were clearly also **human–technology interaction** issues. That is, the technology was not well matched to the users and the context of care. In the pediatrics case, a system developed for medical–surgical units was implemented in a critical care unit.

Human–technology interface problems are the major cause of as many as 87% of all patient monitoring incidents (Walsh & Beatty, 2002). It is not always that the technology itself is faulty. In fact, the technology may perform flawlessly, but the interface design may lead the human user to make errors (Vicente, 2004).

Rice and Tahir (2014) reported on two errors that remind us we still have a long way to go to ensure patient safety. In 2011, a pop-

up box on a digital blood glucose reader was misread, and the patient was given too much insulin, which sent her into a diabetic coma. In 2013, a patient did not receive his psychiatric medicine for almost 3 weeks because the pharmacy's computer system was set to automatically discontinue orders for certain drugs and there was no alert built in to notify the team providing care to this patient that the drug was suspended. The real issue is that the healthcare personnel–technology interfaces continue to cause these adverse events and near misses. It is important to remember that it is not only a technology or human interface issue. Many of these problems occur when new technology is introduced or existing technology is modified. In addition, we must examine how the technology tools are tested, the human users are prepared for their use, and the tools are integrated into the care delivery process (Rice & Tahir, 2014).

The Institute for Safe Medication Practices (2020) reflected on the seminal Institute of Medicine's report, *To Err Is Human*, and developed its top 10 most persistent medication and safety errors/issues. This list includes selecting the wrong medication after entering the first few letters of the drug name, errors due to look-alike labeling of manufacturers' products, misheard drug orders or recommendations during verbal/telephone communication, unsafe ability to override with automated dispensing cabinets (ADCs), unsafe practices associated with IV push medications, and wrong routes. It is important to note that errors and issues have continued more than two decades after the *To Err Is Human* report was issued. These errors are important to review since they reflect the work that has been done while making us aware of how much work is left to do when we add technologies to patient care. Please refer to **Box 11-1**: Interface Applications. We must be cognizant that new issues can arise from combining human factors and technology into patient care (American Society for Health Care and Risk Management, n.d.; The Joint Commission, 2023; Nuber, 2022; Sittig et al., 2018; USF Health, 2023).

BOX 11-1 INTERFACE APPLICATIONS

REFLECT ON THESE INTERFACE APPLICATIONS

Xerox (2023) listed 35 innovations that rocked or changed our world. We selected a few for you to critically think about in relation to how they affect health care.

NATURAL LANGUAGE USER INTERFACES

Natural language processing (NLP) is a discipline of computer science concerning the relationship between computers and human language that requires machine learning skills from the disciplines of AI and computational linguistics. Our virtual assistants, such as Siri, Cortana, and Alexa, can respond to our questions or verbalized needs. As natural language interfaces evolve, they will help us speed up complex processes requiring extensive typing. This will enhance health care by allowing us to do the following:

- Map unstructured text data elements to structured fields in an EHR to improve clinical data reliability and integrity
- Identify key elements, concepts, or phrases in lengthy blocks of a clinical note
- Reverse the process by converting data from machine-readable formats to natural language for reporting functions
- Conduct unique or distinct free text queries requiring multiple data sources to be synthesized to meet the query

THE CAPACITIVE TOUCH SCREEN, OR TOUCH DISPLAY

As opposed to the resistive touch screen, relying on the mechanical pressure made by your finger or a stylus, the capacitive touch screen, or touch display, uses the fact that our bodies are naturally conductive. The use of the electrical charges held in our fingertips makes tapping; swiping; scrolling; and resizing, such as zooming, easier. In the clinical setting, these displays can be used by gloved fingers.

GESTURE RECOGNITION

Gesture recognition requires the interpretation of human gestures via mathematical algorithms. Gestures can originate from any bodily motion, but typically they come from the face or hands. Emotion recognition is evolving.

Healthcare professionals use computer vision-based gesture recognition and wearable sensor-based gesture recognition. Surgeons can access patient data mid-surgery using a gesture, and doctors and nurses can similarly control robots. As pointed out by Xerox (n.d.), "When computers read gestures, the world is your interface" (para. 37).

NEAR FIELD COMMUNICATION INTERFACE AND PROTOCOL

For people to be able to interact with devices and computers, the devices and computers must have smart ways to interact with each other. The standard that defines these communication modes is the **Near Field Communication Interface and Protocol (NFCIP-1)**, which provides the communication network for these devices to be interconnected. This communication network uses **near field communication (NFC)** secure credentialing to network the products and consumer equipment in machine-to-machine or machine-to-object interaction. This provides the security that makes mobile payments practical.

Landman et al. (2014) developed an innovative use for a "**near field communication-enabled medication administration (NFCMA)** system taking advantage of a mobile device equipped with a reader for near field communication (NFC), a wireless communication protocol that allows secure exchange of small amounts of data by proximity or touch" (para. 9). Debnath et al. (2020) reported that their short transmission range makes NFC-based transactions very secure. In 2021, Aldughayfiq and Sampalli (2021) conducted a usability study and determined that an NFC-based mobile application could improve patient safety. The results demonstrate that their subjects thought the NFC application will decrease errors in the dispensing of medications. Landman et al.'s (2014) innovation positively affects medication administration, and NFC continues to be researched.

APPLICATION PROGRAMMING INTERFACE

The **application programming interface (API)** is an interface or communication protocol between a server and a client. It is a computing interface to a software component or a system that defines how other components or systems can use it. The interface can be entirely customized; specific to a component of the system; or designed based on an industry standard to assure interoperability, which is key.

Xerox (n.d.) stated that "[s]oftware is certainly eating the world. But the web wouldn't be what it is without the proliferation of API bridges between all that software" (para. 39).

Healthcare applications involve building interoperability between EHRs, internal apps, and other data exchange tools, which necessitates the need for APIs to govern the flow of information among these disparate, distinct systems.

Improving the Human–Technology Interface

Much can be learned from the related fields of cognitive engineering, human factors, and **ergonomics** (**Figure 11-1** and **Figure 11-2**) about how to make interfaces more compatible with their human users and the context of care. Each of these areas of study is multidisciplinary and integrates knowledge from multiple disciplines (e.g., computer science, engineering, cognitive engineering, psychology, and sociology).

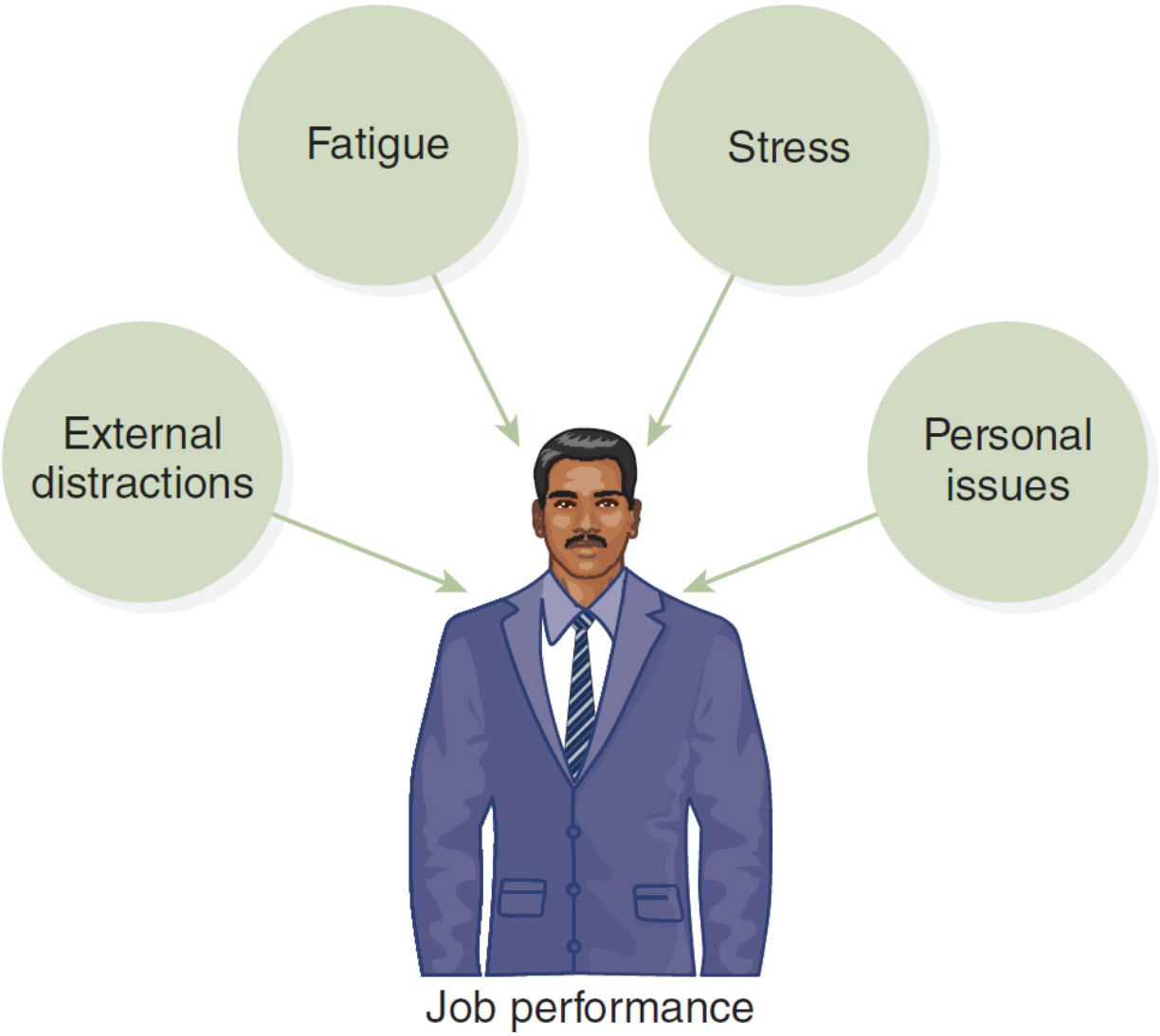


Figure 11-1 Human Factors and Ergonomics

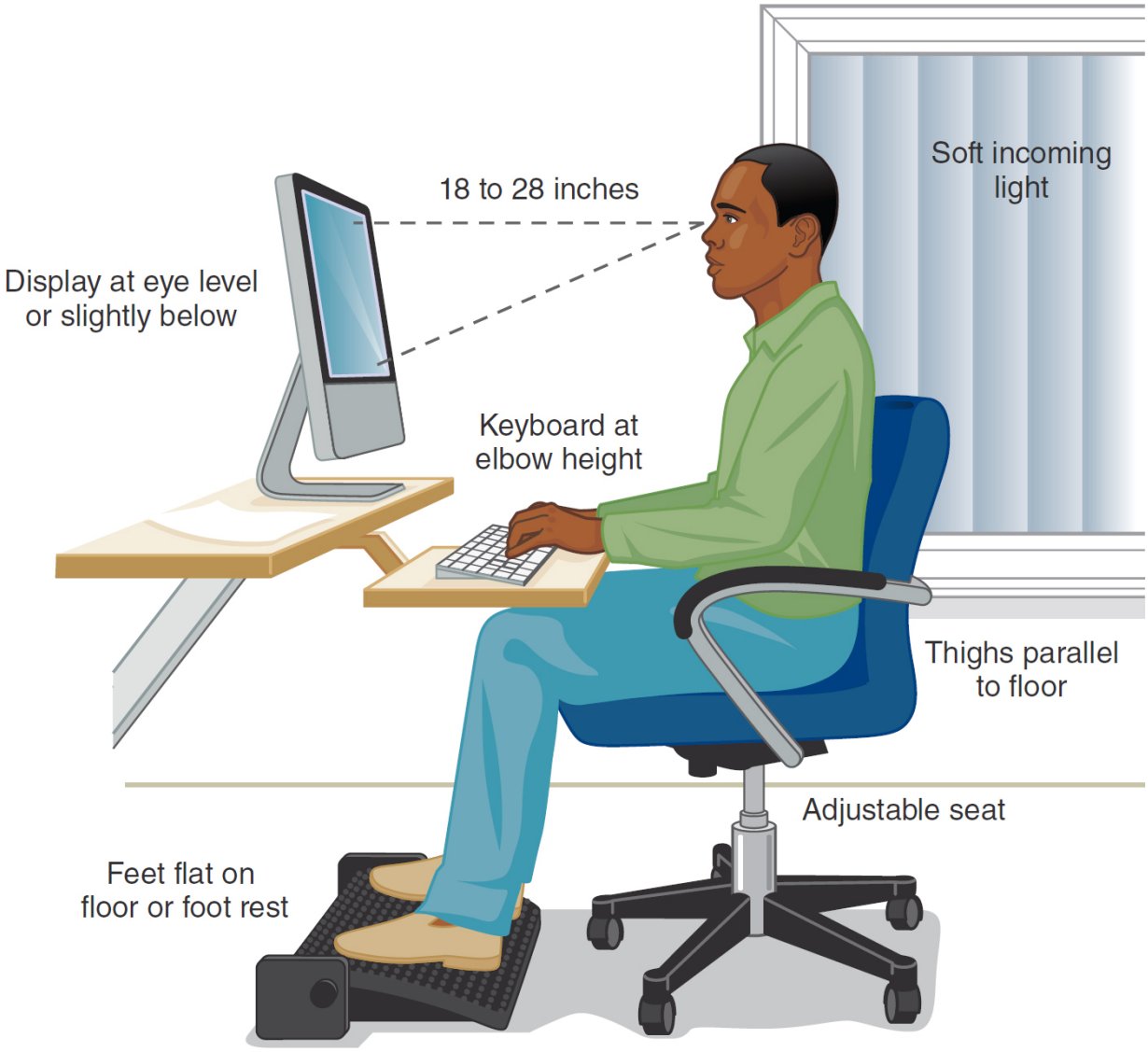


Figure 11-2 Human Factors and Ergonomics, Continued

Description

These areas are also concerned with health issues arising from computer and other technology use. Longo and Reese (2014) reminded us that

> *[n]early 20 years ago, the American Optometric Association termed computer vision syndrome (CVS) as the complex of eye and vision problems related to near work experienced while using a computer. CVS symptoms reflect the current broad diagnosis of asthenopia (ICD-9, 368.13) [2017 ICD-10-CM H53.149] also referred to as eyestrain. Symptoms include: fatigue, blurred distal or proximal vision, headache,*

dry or irritated eyes, neck and/or backaches, blurred near vision and diplopia (double vision). (p. 8)

Longo and Reese (2014) described how to prevent computer vision syndrome. One of the best ways to help your eyes is to remember to look 20 feet away from your screen every 20 minutes for a minimum of 20 seconds. With increased smartphone use, we are seeing neck issues caused by the tilt of the head (with the chin on the chest) while looking down at the smartphone or other handheld device. You should hold your phone up so that you are keeping your neck and eyes aligned properly with the device's screen for more comfortable viewing and interactions. We must all be aware of our posture and how our work areas are set up when using our computers, smartphones, tablets, and any other devices that consume a great deal of our time during our work or personal hours. See **Box 11-2** for how to use a virtual reality headset.

BOX 11-2 VIRTUAL REALITY (VR) HEADSET USAGE

A VR headset, or head-mounted display, is a wearable device that you place over your eyes like goggles and use it to fully engage in the VR environment. Here is a list of human–technology interface tips from the authors:

1. Always read the manufacturer's instructions and safety warnings before using any headset.
2. Place your headset on and adjust it, based on the manufacturer's guidance, so that it feels comfortable; once you enter VR, make sure everything looks crisp and clear.
3. Learn how to hold and use the controllers if applicable. They typically have a wrist strap, and it is suggested to use the strap to prevent the controllers from falling to the floor and being damaged.
4. Clear your space so that you do not have any hazards while you move around in VR such as when you reach and extend your arms or walk around. Some people stay seated when they do not have a large enough area for safe movement.
5. Begin slowly by building the amount of time you spend in VR. Access a program for 5 minutes and evaluate how you feel. If you do not feel any

discomfort, keep the headset on for 15 to 30 minutes engaging in VR activities. If you feel discomfort, remove the headset, discontinue use, and rest. Try again later.

6. It is suggested to take a 10 to 15 minute break for every 30 minutes of VR time or 30 minutes for every hour of VR.
7. As your eyes and brain get accustomed to the headset and VR, you can increase your time in VR. It is not recommended to exceed 1 hour of continuous use, so remember to take breaks. You might even take up to 1-hour breaks after being in VR for 1 hour.
8. Be mindful of your eyes and make sure that you look off into the distance after you remove the headset, just as you would if you are using a monitor and should change your eyes' focus often. Change the visual distance you focus on for your eyes.

In addition, Meta Quest (2023) recommended the following:

1. You must be 13+ years old.
2. Only use indoors (keep headset away from direct sunlight).
3. Take care of your headset by keeping it away from liquids or heat.
4. Read and abide by their [Meta] current code of conduct.
5. To protect youth, adults should monitor how their 13+ teens are using the Meta VR systems.

Meta Quest. (n.d.). *Welcome to the Meta Quest safety center.* www.oculus.com/safety-center

Effken (2006) proposed an ecological approach to interface design to help us realize a more meaningful EHR. The **ecological interface design (EID)** is an approach to interface design that was introduced explicitly for multifaceted, complex sociotechnical, real-time, and dynamic systems; it has been applied in many fields, including health care. This approach supports knowledge workers in health care as they manage and adapt to change, innovation, and novelty. This approach was borrowed from a small field of psychology—ecological psychology—which helps the user identify deviations from normal physical or physiological processes. It is evident that users and clinicians need the technology and interfaces necessary to quickly comprehend the multiple discrete data that are contained in distinct parts of the EHR.

Over the years, three axioms have evolved for developing effective **human–computer interactions**: (1) Users must be an early and continuous focus during interface design; (2) the design process should be iterative, allowing for evaluation and correction of identified problems; and (3) formal evaluation should take place using rigorous experimental or qualitative methods (Staggers, 2003). It is important to note that the following axioms still apply today and that, even after all these years, are often not followed.

Axiom 1: Users Must Be an Early and Continuous Focus During Interface Design

Rubin (1994) used the term *user-centered design* to describe the process of designing products (e.g., human–technology interfaces) so that users can carry out the tasks needed to achieve their goals with "minimal effort and maximal efficiency" (p. 10). Thus, in user-centered design, the end user is emphasized. This is still a focus of human–technology interface design today.

Vicente (2004) argued that technology should fit human requirements at five levels of analysis (i.e., physical, psychological, team, organizational, and political). Physical characteristics of the technology (e.g., size, shape, or location) should conform to the user's size, grasp, and available space. Information should be presented in ways that are consistent with known human psychological capabilities (e.g., the number of items that can be remembered is seven plus or minus two). In addition, systems should conform to the communication, workflow, and authority structures of work teams; to organizational factors, such as culture and staffing levels; and even to political factors, such as budget constraints, laws, or regulations.

A number of analysis tools and techniques have been developed to help designers better understand the task and user environment for which they are designing. Discussed next are task analysis, cognitive task analysis, and cognitive work analysis.

Task analysis examines how a task must be accomplished. Generally, analysts describe the task in terms of inputs needed for the task, outputs (i.e., what is achieved by the task), and any constraints on actors' choices on carrying out the task. Analysts then lay out in flowcharts the sequence of temporally ordered actions that must be carried out to complete the task (Vicente, 1999). A worker's tasks must be analyzed. Task analysis is very useful in defining what users must do and which functions might be distributed between the user and technology (U.S. Department of Health and Human Services, 2013). **Cognitive task analysis** usually starts by identifying, through interviews or questionnaires, the particular task and its typicality and frequency. Then analysts may review the written materials that describe the job or are used for training and determine, through structured interviews or by observing experts perform the task, which knowledge is involved and how that knowledge might be represented. Cognitive task analysis can be used to develop training programs. Zupanc et al. (2015) reported on the use of cognitive task analysis techniques to develop a framework from which a colonoscopy training program could be designed. "Task analysis methods (observation, a think-aloud protocol and cued-recall) and subsequent expert review were employed to identify the competency components exhibited by practicing endoscopists with the aim of providing a basis for future instructional design" (p. 10). The resulting colonoscopy competency framework consisted of "twenty-seven competency components grouped into six categories: clinical knowledge; colonoscope handling; situation awareness; heuristics and strategies; clinical reasoning; and intra and inter-personal" (p. 10).

Cognitive work analysis (CWA) was developed specifically for the analysis of complex, high-technology work domains, such as nuclear power plants, intensive care units, and emergency departments, where workers need considerable flexibility in responding to external demands (Burns & Hajdukiewicz, 2004; Vicente, 1999). A complete CWA includes five types of analysis: (1) work domain, (2) control tasks, (3) strategies, (4) social–organizational, and (5) worker competencies. The work domain

analysis describes the functions of the system and identifies the information that users need to accomplish their task goals. The control task analysis investigates the control structures through which the user interacts with or controls the system. It also identifies which variables and relations among variables discovered in the work domain analysis are relevant for particular situations so that context-sensitive interfaces can present the right information (e.g., prompts or alerts) at the right time. The strategies analysis looks at how work is actually done by users to facilitate the design of appropriate human–computer dialogues. The social–organizational analysis identifies the responsibilities of various users (e.g., doctors, nurses, clerks, or therapists) so that the system can support collaboration, communication, and a viable organizational structure. Finally, the worker competencies analysis identifies design constraints related to the users themselves (Effken, 2002).

Specialized tools are available for the first three types of CWA (Vicente, 1999). Analysts typically borrow tools (e.g., ethnography) from the social sciences for the two remaining types. Hajdukiewicz et al. (2001) used CWA to model an operating room environment. Effken (2002) and Effken et al. (2001) used CWA to analyze the information needs for an oxygenation management display for an intensive care unit. Other examples of the application of CWA in health care are described by Burns and Hajdukiewicz (2004) in their book, *Ecological Interface Design*. Ashoori et al. (2014) used team CWA to reveal the interactions of the healthcare team in the context of work models in a birthing unit. They felt that team CWA enhances CWA in complex environments, such as health care, that require effective teamwork because it reveals additional constraints relevant to the workings of the team. The information gleaned about the teamwork could be used for systems design applications.

Axiom 2: The Design Process Should Be Iterative, Allowing for Evaluation and Correction of Identified Problems

Today, both principles and techniques for developing human–technology interfaces that people can use with minimal stress and maximal efficiency are available. An excellent place to start is with Norman's (1988, pp. 188–189) principles:

1. Use both knowledge in the world and knowledge in the head. In other words, pay attention not only to the environment or to the user but to both, and to how they relate. By using both, the problem actually may be simplified.
2. Simplify the structure of tasks. For example, reduce the number of steps or even computer screens needed to accomplish the goal.
3. Make things visible. Bridge the **gulf of execution** and the **gulf of evaluation**. Users need to be able to see how to use the technology to accomplish a goal (e.g., which buttons does one press and in which order to program this PCA?); if they do, then designers have bridged the gulf of execution. They also need to be able to see the effects of their actions on the technology (e.g., if a nurse practitioner prescribes a drug to treat a certain condition, the actual patient response may not be perfectly clear). This bridges the gulf of evaluation.
4. Get the mappings right. Here, the term ***mapping*** is used to describe how environmental facts (e.g., the order of light switches or variables in a physiologic monitoring display) are accurately depicted by the information presentation.
5. Exploit the power of constraints, both natural and artificial. Because of where the eyes are located in the head, humans have to turn their heads to see what is happening behind them; however, that is not true of all animals. As the location of one's eyes constrains what one can see, so also do physical elements, social factors, and even organizational policy constrain the way tasks are accomplished. By taking these constraints into account when designing technology, it can be made easier for human use.

6. Design for error. Mistakes happen. Technology should eliminate predictable errors and be sufficiently flexible to allow humans to identify and recover from unpredictable errors.
7. When all else fails, standardize. To get a feel for this principle, think how difficult it is to change from a Macintosh to a Windows environment or from the iPhone operating system to Android.

Kirlik and Muruyama (2004) described a real-world human–technology interface that follows Norman's principles. In their classic analogy, the authors observed how a busy expert short-order cook strategically managed to grill many hamburgers at the same time and each to the customer's desired level of doneness. The cook put the burgers that were to be well done on the back and far right portion of the grill, those to be medium well done in the center of the grill, and those to be rare at the front of the grill but farther to the left. The cook moved all the burgers to the left as grilling proceeded and turned them over during their travel across the grill. Everything the cook needed to know was available in this simple interface. As a human–technology interface, the grill layout was elegant. The interface used knowledge housed in both the environment and the expert cook's head; also, things were clearly visible, both the position of the burgers and the way they were moved. The process was clearly and effectively standardized, with built-in constraints. What might it take to create such an intuitive human–technology interface in health care?

Several useful books have been written about effective interface design (e.g., Burns & Hajdukiewicz, 2004; Cooper, 1995; Mandel, 1997; McKay, 2013; Wigdor & Wixon, 2011). Just as in other industries, health care is learning that big data can provide big insights if they can be visualized, accessed, and meaningful (Intel, n.d.). Often, designers use graphical objects to show how variables relate. The first to do so were likely Cole and Stewart (1993), who used changes in the lengths of the sides and area of a four-sided object to show the relationship of respiratory rate to tidal volume. Other researchers have demonstrated that histograms and polygon

displays are better than numeric displays for detecting changes in patients' physiological variables (Gurushanthaiah et al., 1995). When Horn et al. (2001) presented physiological data via a single circular object with 12 sectors (where each sector represented a different variable), nurses reported that it was easy to recognize abnormal conditions but difficult to comprehend the patient's overall status. This kind of graphical object approach has been most widely used in anesthesiology, where a number of researchers have shown improved clinician **situational awareness** or problem-detection time by mapping physiological variables onto display objects that have meaningful shapes, such as using a bellows-like object to represent ventilation (Agutter et al., 2003; Blike et al., 2000; Michels et al., 1997; Zhang et al., 2002).

Effken (2006) compared a prototype display that represented physiological data in a structured pictorial format with two bar graph displays. Both the first bar graph display and the prototype presented data in the order that experts were observed to use them. The second bar graph display presented the data in the way that nurses collected them. In an experiment in which resident physicians and novice nurses used simulated drugs to treat observed oxygenation management problems using each display, residents' performance was improved with the displays ordered as experts used them, but nurses' performance was not improved. Instead, nurses performed better when the variables were ordered as they were used to collecting them, which demonstrated the importance of understanding user roles and the tasks they need to accomplish.

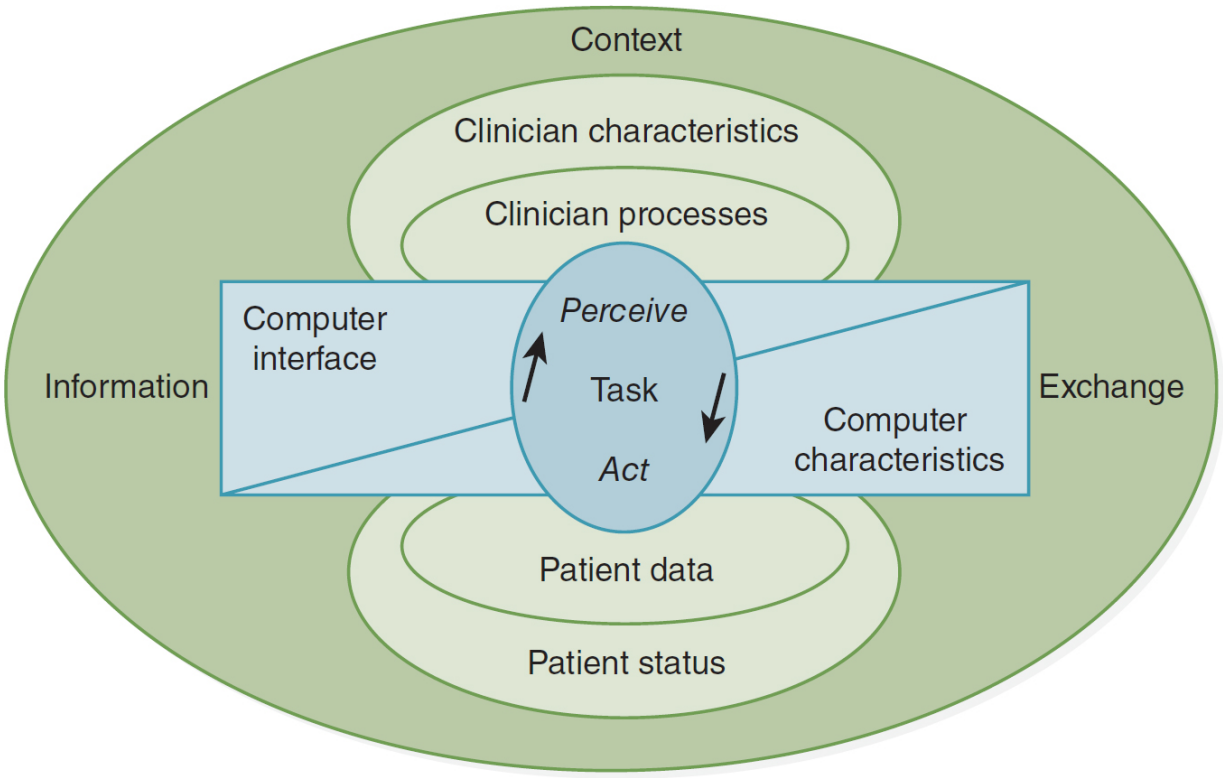
Data also must be represented in ways other than visually. Gaver (2010) proposed that because ordinary sounds map onto familiar events, they could be used as icons to facilitate easier technology navigation and use and provide continuous background information about how a system is functioning. In health care, auditory displays have been used to provide clinicians with information about patients' vital signs (e.g., in pulse oximetry), such as by altering volume or tone when a significant change occurs (Sanderson, 2006).

Admittedly, auditory displays are probably more useful for quieter areas of the hospital, such as the operating room. Perhaps that is

why researchers have most frequently applied the approach in anesthesiology. For example, Loeb and Fitch (2002) reported that anesthesiologists detected critical events more quickly when auditory information about heart rate, blood pressure, and respiratory parameters was added to a visual display. An **earcon** is a brief or short distinctive sound representing a specific event or conveying some other bit of information such as the sound from your phone when you receive an email or a text that alerts you to check for the information just received. These are common in computer systems and applications, such as the computer beep signifying there is an error or a distinct sound indicating that a patient has allergies or something else that needs your attention. Auditory tones also have been combined as earcons to represent relationships among data elements, such as the relationship of systolic to diastolic blood pressure (Watson & Gill, 2004).

Axiom 3: Formal Evaluation Should Take Place Using Rigorous Experimental or Qualitative Methods

Perhaps one of the highest accolades that any interface can achieve is to say that it is transparent. An interface becomes transparent when it is so easy to use that users think only about the task at hand instead of the interface. For example, a transparent clinical interface would enable clinicians to focus on patient decisions rather than on how to access or combine patient data from multiple sources. In **Figure 11-3**, instead of the nurse interacting with the computer, the nurse and the patient interact through the technology interface. The more transparent the interface, the easier the interaction should be.



Modified from: Staggers, N., & Parks, P. L. (1993). Description and initial applications of the Staggers & Parks nurse–computer interaction framework. *Computers in Nursing, 11,* 282–290. Reprinted by permission of AMIA.

Figure 11-3 Nurse–Patient Interaction Framework in Which the Technology Supports the Interaction

Description

Usability is a term that denotes the ease with which people can use an interface to achieve a particular goal. Usability of a new human–technology interface needs to be evaluated early and often throughout its development. Typical usability indicators include ease of use, ease of learning, satisfaction with using, efficiency of use, error tolerance, and fit of the system to the task (Staggers, 2003). Some of the more commonly used approaches to usability evaluation are discussed next.

Surveys of Potential or Actual Users

Chernecky et al. (2006) assessed cancer patients' preferences for website design. Participants were asked their preferences for a number of design characteristics, such as display color, menu buttons, text, photo size, icon metaphor, and layout, by selecting on a computer screen their preferences for each item from two or three options.

Focus Groups

Typically used at the very start of the design process, focus groups can help the designer better understand users' responses to potential interface designs and to content that might be included in the interface.

Cognitive Walkthrough

In a **cognitive walkthrough**, evaluators assess a paper mock-up, working prototype, or completed interface by observing the steps users are likely to take to use the interface to accomplish typical tasks. This analysis helps designers determine how understandable and easy to learn the interface is likely to be for these users and their typical tasks (Wharton et al., 1994).

Heuristic Evaluation

A **heuristic evaluation** has become the most popular of what are called discount usability evaluation methods. The objective of a heuristic evaluation is to detect problems early in the design process, when they can be most easily and economically corrected. The methods are called discount because they typically are easy to do, involve fewer than 10 experts (often experts in relevant fields, such as human–computer technology or cognitive engineering), and are much less expensive than other methods. They are called heuristic because evaluators assess the degree to which the design complies with recognized usability rules of thumb or principles (the heuristics), such as those proposed by Nielsen (1994) and available on his website (www.useit.com/papers/heuristic/heuristic_list.html).

For example, McDaniel and colleagues (2002) conducted a usability test of an interactive computer-based program to

encourage smoking cessation by low-income women. As part of the initial evaluation, healthcare professionals familiar with the intended users reviewed the design and layout of the program. The usability test revealed several problems with the decision rules used to tailor content to users, which were corrected before implementation.

Formal Usability Test

Formal usability tests typically use either experimental or observational studies of actual users using the interface to accomplish real-world tasks. A number of researchers use these methods. For example, Staggers et al. (2007) conducted a usability study of a prototype electronic medication administration record. Participants were asked to add, modify, or discontinue medications using the system. The time they needed to complete the task and their accuracy in the task and satisfaction with the prototype were assessed (the last criterion through a questionnaire). Although satisfaction was high, the evaluation also revealed design flaws that could be corrected before implementation.

Field Study

In a **field study**, end users evaluate a prototype in the actual work setting just before its general release. For example, Thompson et al. (2007) evaluated the use of touch-screen computer kiosks containing child health–promoting information in several low-income urban community settings through an online questionnaire that could be completed after the kiosk was used. Most users found the kiosk easy to use and the information it provided easy to understand. Researchers also gained a better understanding of the characteristics of the likely users (e.g., 26% had never used the internet, and 48% had less than a high school education) and the information most often accessed (i.e., television and media use and smoke exposure).

Dykes and her colleagues (2006) used a field test to investigate the feasibility of using digital pen and paper technology to record vital signs as a way to bridge an organization from paper to an EHR. In general, satisfaction with the tool increased with use, and the

devices conformed well to nurses' workflow. However, 8% of the vital sign entries were recorded inaccurately because of inaccurate handwriting recognition, entries outside the recording box, or inaccurate data entry (i.e., the data entered were not valid values). The number of modifications needed in the tool and the time that would be required to make those changes ruled out using the digital pen and paper as a bridging technology.

Ideally, every healthcare setting would have a usability laboratory of its own to test new software and technology in its own setting before actual implementation. However, having such a laboratory can be expensive, especially for small organizations. Kushniruk and Borycki (2006) developed a low-cost, rapid usability engineering method for creating a portable usability laboratory, consisting of video cameras and other technology, which can be taken out of the laboratory into hospitals and other locations to test the technology on-site using as close to a real-world environment as possible. An on-site usability laboratory is a cost-effective and efficient solution, which makes it possible to test all technologies before their implementation.

A Framework for Evaluation

Ammenwerth et al. (2006) proposed a fit between individuals, tasks, and technology (FITT) model that suggests that each of these factors be considered in designing and evaluating human–technology interfaces. It is not enough to consider only the user and technology characteristics; the tasks that the technology supports must be considered as well. The FITT model builds on DeLone and McLean's (1992) information success model, Davis's (1993) technology acceptance model, and Goodhue and Thompson's (1995) task technology fit model. A notable strength of the FITT model is that it encourages the evaluator to examine the fit between the various pairs of components: user and technology, task and technology, and user and task.

Johnson and Turley (2006) compared how doctors and nurses describe patient information and found that doctors emphasized diagnosis, treatment, and management, whereas the nurses emphasized functional issues. Although both physicians and nurses share some patient information, how they thought about patients differed. For that reason, an EHR needs to present information (even the same information) to the two groups in different ways.

Hyun et al. (2009) used a combination of two models (i.e., technology acceptance model and task–technology fit model) to design and evaluate an electronic documentation system for nurses. To facilitate the design, they employed multiple methods, including brainstorming of experts, to identify design requirements. To evaluate how well the prototype design fit both task and user, nurses were asked to carry out specific tasks using the prototype in a laboratory setting and then complete a questionnaire on ease of use, usefulness, and fit of the technology with their documentation tasks. Because the researchers engaged nurses at each step of the design process, the result was a more useful and usable system.

It is easy to see how the foundational work of all these early pioneers have helped to shape our views of human–technology

interfacing. They laid the groundwork for us to leverage technology while considering the human–technology interface for our own health and safety and also for our patients and their significant others.

Future of the Human–Technology Interface

Increased attention to improving the human–technology interface through human factors approaches has already led to significant improvements in one area of health care: anesthesiology. Anesthesia machines that once had hoses that would fit into any delivery port now have hoses that can be plugged in to only the proper port. Anesthesiologists have also been actively working with engineers to improve the computer interface through which they monitor their patients' status and are among the leaders in investigating the use of audio techniques as an alternative way to help anesthesiologists maintain their situational awareness. As a result of these efforts, anesthesia-related deaths dropped from 2 in 20,000 to 1 in 200,000 in less than 10 years (Vicente, 2004). It is hoped that continued emphasis on human factors (Vicente, 2004) and user-centered design (Rubin, 1994) by informatics professionals and human–computer interactions experts will have equally successful effects on other parts of the healthcare system. The increased amount of informatics research in this area is encouraging, but there is a long way to go.

A systematic review of clinical technology design evaluation studies (Alexander & Staggers, 2009) found 50 nursing studies. Of those studies, nearly half (24) evaluated effectiveness, fewer (16) evaluated satisfaction, and still fewer (10) evaluated efficiency. The evaluations were not systematic; that is, there was no attempt to evaluate the same system in different environments or with different users. Most evaluations were done in a laboratory rather than in the setting where the system would be used. The authors argued for a broader range of studies that use an expanded set of outcome measures. For example, instead of looking at user satisfaction, evaluators should dig deeper into the design factors that led to the satisfaction or dissatisfaction. In addition, performance measures, such as diagnostic accuracy, errors, and correct treatment, should be used.

Barth (2013) reported on a social study of the human cloud formed in part by data collected from wearable technologies; they focused on assessing attitudes and exploring how cloud computing is enabling this new generation of smart devices. Today, smartphones, glasses, clothing, watches, cameras, and monitors for health or patient tracking, to name but a few devices, are available for this purpose.

Wearable technology, or the field of mobile smart devices that are worn on our bodies, is the current rapidly evolving human–technology interface. Booth (2019) stated that "[r]oughly 60 million Americans use wearable devices" (para. 1), which include gloves, body gear, and headsets. Booth reported that for the most part, wearables consist of shrinking smartphone technology—for example, taking the smartphone's display and adding it to a watch. However, the next new frontier is creating wearable devices that not "only read signals from the human body but also intersect and interject signals into the human body" (para. 5). Marr (2020) stated that this industry began with fitness trackers and has "now exploded into a whole industry of wearable technology designed to improve human performance and help us live healthier, safer, more efficient lives. In the future, we may even see humans merge with technology to create 'augmented humans' or 'transhumans'" (para. 4). With these developments, it will be critical for the human–technology interfaces to accommodate the needs of varied users with numerous personal and healthcare needs and lifestyles.

The technologies that are entering our lives on a daily basis can enhance or challenge our ability to complete both our activities of daily living and our professional tasks. As our home monitoring and patient technologies increase, the user's (i.e., patient's or nurse's) ability to use the technology is paramount. No matter who is using the technology, the human–technology interface addresses the user's ability and the technology's functionality to complete the task's demands (see **Figure 11-4**).

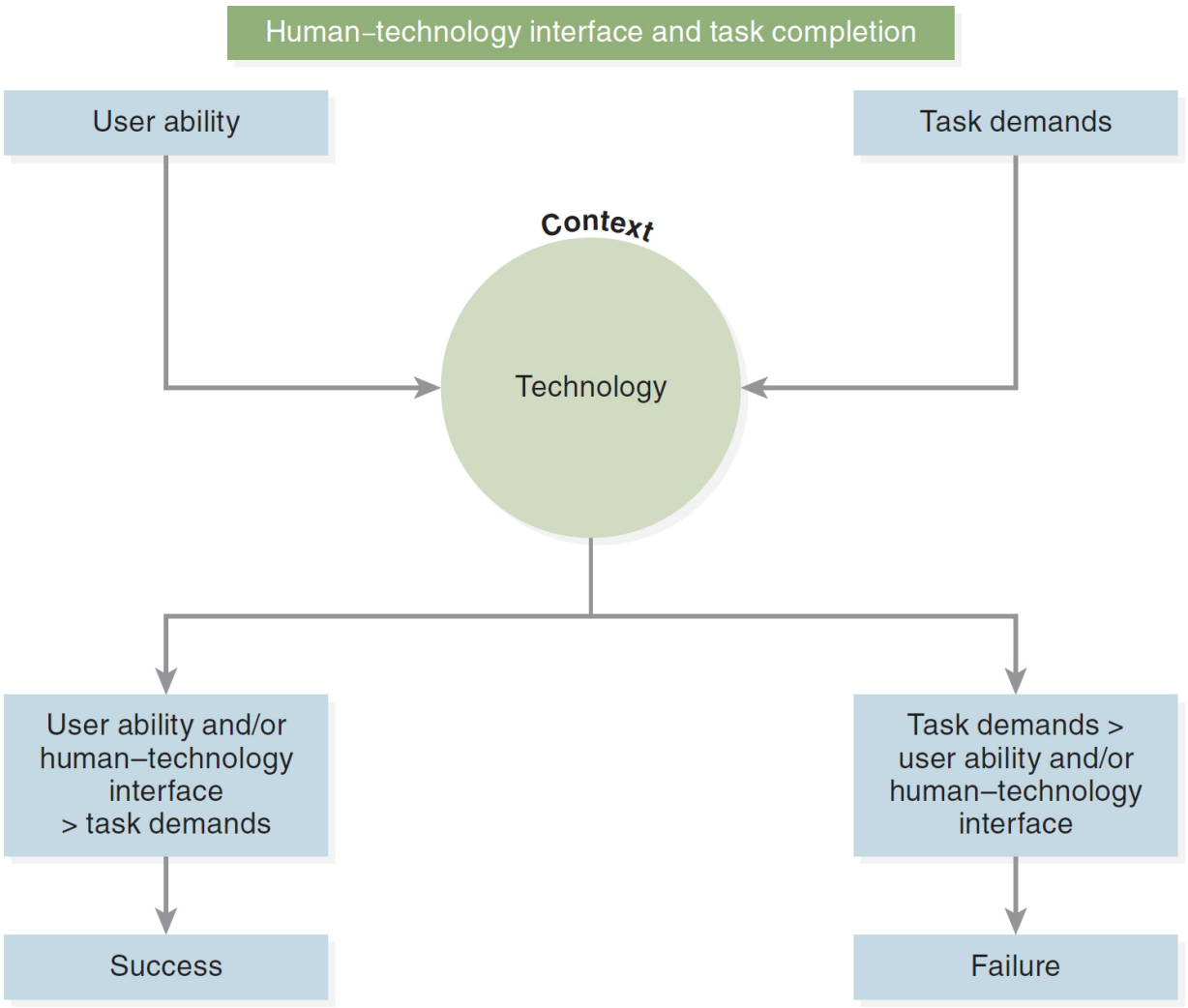


Figure 11-4 Human–Technology Interface and Task Completion

Description

As our technologies continue to evolve, we are creating more design issues. The proliferation of smart devices and wearable technology brings new concerns related to human–technology interfaces. According to Ferreira et al. (2021), wearable technologies are adding another wrinkle into the design process—namely, human behavior. How will someone use this technology? How will individuals behave with it on their person? How will they wear it? How and when will they enable and use it? Will others be able to detect the technologies (i.e., will someone be able to wear Google Glass and take pictures or videos of other people's actions without their

knowing), and will users be able to seamlessly move among all the capabilities of their wearable technologies? We have a long way to go in addressing these issues.

Futurside (2022) reported that the future of "human-computer interfaces is increasingly complex and dynamic, as organizations continue to look for ways to increase efficiency" (para. 14). We are learning how to interact with the new technology, and it is the "wild west when it comes to voice, VR and wearables, but these technologies aren't going anywhere. In fact, they are laying the foundation for a future where humans and computers are tied more closely together than ever before" (Bieller, 2022, para. 32). Bechtel (n.d.) believed "[t]he 'Age of With'—human work augmented and enhanced with AI—is upon us. How will rapidly evolving artificial intelligence technology shape the future of how we live and work?" (para. 1). We will continue to experience major advances and influences that are impacting our machine interactions, human–technology interfacing, especially when you consider how fast AI text and image generators exploded into our awareness and affected our personal and professional lives. "AI is neither hero nor villain. Rather, it represents our species' latest in a long series of hacks: This time, offloading discernment and decision-making" (Bechtel, n.d., para. 24). As new technologies disrupt, it is up to us to learn, leverage, harness, and control their effect and the human–technology interface.

Summary

There are at least three messages the reader should take away from the discussion in this chapter. First, if there is to be significant improvement in quality and safety outcomes in the United States through the use of information technology, the designs for human–technology interfaces must be radically improved so that the technology better fits human and task requirements. However, that improvement will be possible only if clinicians identify and report problems rather than simply creating workarounds. This means that each clinician has a responsibility to participate in the design process and to report designs that do not work.

Second, a number of useful tools are currently available for the analysis, design, and evaluation phases of development life cycles. They should be used routinely by informatics professionals to ensure that technology better fits both task and user requirements.

Third, focusing on interface improvement using these tools has had a huge effect on patient safety in the area of anesthesiology and medication administration. With increased attention from informatics professionals and engineers, the same kind of improvement should be possible in other areas, regardless of the technologies actually employed there. In an ideal world, one can envision that every human–technology interface would be designed to enhance users' workflow, as easy to use as banking ATMs, and fully tested before its implementation in a setting that mirrors that in which it would be used.

THOUGHT-PROVOKING QUESTIONS

1. You are a member of a team that has been asked to evaluate a prototype smartphone-based application for calculating drug dosages. Based on what you know about usability testing, which kind of tests might you do and why?

2. Is there a human–technology interface that you have encountered that you think needs improvement? If you were to design a replacement, which analysis techniques would you choose? Why?
3. Which type of functionality and interoperability would you want from your smartphone, watch, clothing, glasses, headset, camera, and monitor? Provide a detailed response.
4. If you reflect on Marr's (2020) statement, "In the future, we may even see humans merge with technology to create 'augmented humans' or 'transhumans'" (para. 4), do we need to redefine human–technology interfacing? Please provide a detailed rationale for your answer. If you respond no, why wouldn't the interfacing need to be redefined? If you respond yes, how would the interfacing need to be changed?
5. Reflect on AI. How would you describe AI to someone who has not experienced it? How has AI caused disruption? Explain in detail how we should learn, leverage, harness, and control AI's effect and the human–technology interface.

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CHAPTER 12

Electronic Security

OBJECTIVES

1. Assess processes for securing electronic information in a computer network.
2. Identify various methods of user authentication and relate authentication to the security of a network.
3. Consider methods for anticipating and preventing typical threats to network security.

KEY TERMS

- antivirus software
- authentication
- baiting
- biometrics
- blockchain
- brute force attack
- cloud computing
- confidentiality
- data loss prevention (DLP)
- distributed ledger technology (DLT)
- electronic protected health information (EPHI)
- firewall
- flash drive
- hacker
- integrity

- intrusion detection device
- intrusion detection system
- jump drive
- malicious code
- malicious insider
- malware
- mask
- negligent insider
- network
- network accessibility
- network availability
- network security
- password
- phishing
- proxy server
- radio-frequency identification (RFID)
- ransomware
- scareware
- secure information
- security breach
- shoulder surfing
- social engineering
- spear phishing
- spyware
- thumb drive
- Trojan horse
- use case
- virtual desktop interface (VDI)
- virus
- worm
- zero day attack

Introduction

In addition to complying with the guidelines of the Health Insurance Portability and Accountability Act (HIPAA) and the Health Information Technology for Economic and Clinical Health (HITECH) Act regarding the privacy of patient information, healthcare systems need to be vigilant in the way they secure information and manage network security. Many have discussed and will continue to discuss the vulnerability of electronic health records to data breaches (Alder, 2021; McKeon, 2023; Mowry & Oakes, 2011). Mowry and Oakes (2011) suggested that as many as 77 people could view a patient's record during a hospital stay. One of the largest healthcare data breaches, over 3.5 million records, resulted from the hacking of a firewall vendor (Alder, 2021). Another third-party data breach was reported by McKeon (2023); this attack affected the information technology (IT) infrastructure and resulted in the loss of patient data since IT could not access or retrieve patient information. It is critical for IT policies and procedures to ensure appropriate access by clinicians and protect private information from inappropriate access. However, authentication procedures can be cumbersome and time-consuming, thus reducing clinicians' performance efficiency.

Physicians spend on average 7 minutes per patient encounter, with nearly 2 minutes of that time being devoted to managing logins and application navigation. Likewise, an average major healthcare provider must deal with more than 150 applications—most requiring different user names and passwords—which makes it difficult for caregivers to navigate and receive contextual information. Healthcare organizations must strike the right balance between simplifying access to core clinical data sets and maximizing the time providers can interact with patients without jeopardizing data integrity and security (Mowry & Oakes, 2011). AHIMA (n.d.) stated that "[d]ata quality and integrity requires consideration of privacy and security issues, including the protection of data against risks such as loss or unauthorized access, destruction, use, modification,

or disclosures of data by parties not authorized to do so" (para. 7). This chapter explores the use of information and the processes for securing information in a health system computer network.

Securing Network Information

Typically, a healthcare organization has computers linked together to facilitate communication and operations within and outside the facility. These linked computers are commonly referred to as a **network**. The linking of computers together and to the outside world creates the possibility of a breach of **network security** and exposes the information to unauthorized use. With the advent of smart devices, managing all these risks has become a nightmare for some institutions' security processes. In the past, stationary devices and computers resided within healthcare facilities. Today, smart devices travel in and out of healthcare organizations with patients, family members, and other visitors as well as employees—both staff and healthcare providers alike. Since wireless medical devices are becoming more advanced while being increasingly integrated into health care to enhance access and provide quality care, there are substantial security risks associated with their use. Medical devices such as insulin pumps and pacemakers must share data and information over the internet across networks and devices requiring that they are and remain cyber secure (Sullivan, 2012; U.S. Food and Drug Administration, 2022).

The three main areas of secure network information are confidentiality, availability, and integrity. An organization must follow a well-defined policy to ensure that private health information remains appropriately confidential. The **confidentiality** policy should clearly define which data are confidential and how those data should be handled. Employees also need to understand the procedures for releasing confidential information outside the organization or to others within the organization and know which procedures to follow if confidential information is accidentally or intentionally released without authorization. In addition, the organization's confidentiality policy should contain consideration for elements as basic as the placement of monitors so that information cannot be read by passersby. **Shoulder surfing**, which is watching

over someone's back as that person is working, is still a major way that confidentiality is compromised.

Availability refers to network information being accessible when needed. This area of the policy tends to be much more technical in nature. An accessibility policy covers issues associated with protecting the key hardware elements of the computer network and the procedures to follow in case of a major electrical or internet outage. Food and drinks spilled onto keyboards of computer units, dropping or jarring hardware, and electrical surges or static charges are examples of ways that the hardware elements of a computer network may be damaged. In the case of an electrical outage or a weather-related disaster, the network administrator must have clear plans for data backup, storage, and retrieval. There must also be clear procedures and alternative methods of ensuring that care delivery remains largely uninterrupted.

Another way organizations protect the availability of their networks is to institute an acceptable use policy. Elements covered in such a policy could include which types of activities are acceptable on the corporate network. For example, are employees permitted to download music at work? Restricting downloads is a very common way for organizations to prevent **viruses** and other **malicious code** from entering their networks. The policy should also clearly define which activities are not acceptable and identify the consequences for violations.

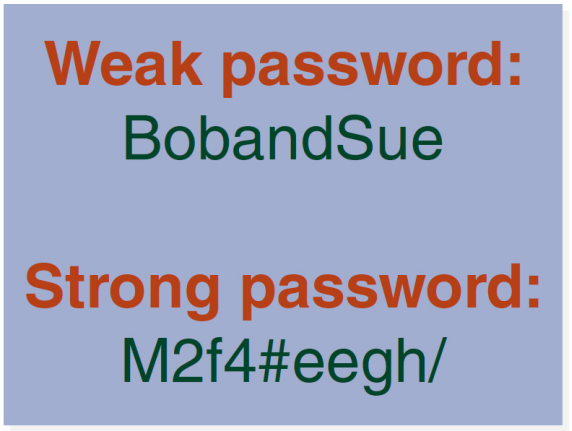
The last area of information security is **integrity**. Employees must have confidence that the information they are reading is true. To accomplish this, organizations need clear policies to clarify how data are actually inputted, determine who has the authorization to change such data, and track how and when data are changed. All three of these areas use authorization and authentication to enforce the corporate policies. Access to networks can easily be grouped into areas of authorization (e.g., users can be grouped by job title). For example, anyone with the job title of "floor supervisor" might be authorized to change the hours worked by an employee, whereas an employee with the title of "patient care assistant" could not make such changes.

Authentication of Users

Organizations also use **authentication** of employees in their security policies. The most common ways to authenticate a user rely on something the user knows, has, or is (**Figure 12-1**).



(A)



(B)



(C)

A. © Photos.com. **C.** © Gary James Calder/Shutterstock, Inc.

Figure 12-1 Ways to Authenticate Users: **A.** An ID Badge. **B.** Examples of Weak and Strong Passwords. **C.** A Finger on a Biometric Scanner.

Something a user knows is a **password**. Most organizations today enforce a strong password policy because free software available on the internet can break a password from the dictionary very quickly. Strong password policies include using combinations of letters; numbers; and special characters, such as plus signs (+) and ampersands (&). Some organizations are suggesting the use of passphrases to increase the strength of a password. See **Box 12-1** for an overview of best practices for creating strong passwords. Policies typically include the enforcement of changing passwords every 30 or 60 days. Passwords should never be written down in an obvious place, such as a sticky note attached to the monitor or under the keyboard.

BOX 12-1 BEST PRACTICES FOR CREATING AND MANAGING PASSWORDS

DO

- Review the specific system guidelines for users; most of them will have information on password parameters and allowable characters.
- Use characters and symbols instead of letters, such as special characters (e.g., !, $, %, &, *).
- Create exclusive passwords for each account.
- Use longer passwords because they are harder to crack. Consider more than eight characters, and if the system allows, expand your password to 12 or 14 characters.
- Choose a password that is based on a phrase. Use portions or abbreviations of the words in the phrase, or use substitutions (e.g., $ for *S*, 4 for *for*) to create the password. For example, the phrase is "'Lucy in the Sky with Diamonds' was released in 1967," and the password is LUit$wdia67.
- Use at least four-word passphrases that seem obscure such as "kittens laugh bark catamaran." This is easier to recall and less able to be hacked.
- After you create it, assess your password's strength if the site provides a password analyzer that will indicate its strength or weakness.

- Think carefully about the password, and create something that you will remember but that uses these different strategies to increase its strength.
- Change your password frequently, and do so immediately if you believe your system or email has been hacked. Some sites or organizations require you to change your password every 60 to 120 days. They also restrict how many recent passwords would not be able to be reused.
- Enable two-factor authentication, also referred to as multifactor authentication. Even if someone hacks your password, they would not be able to access your account if you also require a code to be sent to your phone. The hacker would then need your phone and your password.
- Use a password generator to obtain a randomized, more secure password.
- Consider using a password manager program to help you create strong passwords and store them securely.
- Check your username and password to see if your credentials were included in any recent data breaches using a security tool such as Have I Been Pwned? (https://haveibeenpwned.com).

DO NOT

- Share your password with anyone.
- Post your passwords in plain sight.
- Never use personal information such as your pet's name, phone number, address, bank account, or birthday. Avoid the birthdays of your significant others too.
- Use dictionary words.
- Use a string of numbers.
- Make simple changes to your old passwords, such as your current password being golf.players3 and your new password being golf.players4. It is best to create an entirely new password.
- Use keyboard strings or patterns that can be replicated such as fr5tghy6 or olp098.
- Use the same password for multiple sites.

Terwillegar, T. (2023, July 17). *10 essential password security best practices.* Liquid Web. www.liquidweb.com/blog/password-security-best-practices

The second area of authentication is something the user has, such as an identification (ID) card. ID cards can be magnetic, similar to a credit card, or have a **radio-frequency identification (RFID)** chip embedded into the card.

The last area of authentication is **biometrics**. Devices that recognize thumbprints or retina or facial patterns are available. Depending on the level of security needed, organizations commonly use a combination of these types of authentication.

Blockchain

A **blockchain** is a digital database containing a record of transactions, maintained across several computers linked in a network, that can be simultaneously used and shared within a large, decentralized publicly accessible network. Transactions are logged publicly in chronological order. The database displays an ever-increasing list of ordered blocks; each block is time-stamped and connected to the block that came before it, thereby establishing a blockchain. Marr (2020) stated that a blockchain is a "super-secure method of storing, authenticating, and protecting data [that] could revolutionize many aspects of business—particularly when it comes to facilitating trusted transactions" (para. 7). It is important to note that each block cannot be altered, deleted, or otherwise modified since it is a permanent record that a given transaction has occurred. Blockchain technology lends itself well to the management of health records and proving identity, based on its security features. To provide multiple layers of security, healthcare organizations could restrict the connection points or network nodes in their communication network to only the HIPAA-covered entities, encrypt some data, and leave other data off blockchain (Alder, n.d.; Miliard, 2017). Visibility and accountability are strengths, but it is important to note that not all blockchains must be publicly available.

BLOCKCHAIN APPLICATIONS IN HEALTH CARE

Healthcare research could be facilitated by blockchain technology since the technology could generate a layer of de-identified data that researchers could access. Blockchain technology could enact patient-centered care by positioning the patient at the center of the healthcare delivery system while improving privacy, security, and interoperability.

Healthcare settings have numerous ways to enter the patient's date of birth, and the date cannot be standardized after it has been entered. Blockchain can

be used in this case by linking patients to their data instead of to their identity. Blockchain can also conduct identity management of the healthcare provider.

Use Case for Blockchain Technology

A **use case** describes a distinct situation in which a specific product or service could possibly be used. The following use case focuses on blockchain technology.

Blockchain Use Case: Insurance Claim Processing

The goal of this use case was to automate health insurance claim processing by demonstrating the application of blockchain to the insurance industry and specifically in health care. Blockchain technology maintains the patient's privacy while allowing data to be shared between entities in a synchronized and secured process. The benefits of using blockchain include improved efficiency, better trust and control, faster claims processing, smart contract capabilities, and fraud prevention. Using blockchain in health care "can reduce the costs and inefficiencies associated with processing and paying healthcare claims, thereby combating fraudulent activities. Blockchain can reduce the time needed to process claims by storing data and automating the validation process" (Gyan Solutions, 2023, para. 16).

Preauthorization payment claim transactions must be verifiable and smart contract–enabled **distributed ledger technology (DLT)** leveraged. DLT is a technological infrastructure with protocols to simultaneously access, validate, record, share, coordinate, and synchronize transactions in electronic ledgers across a network that spans numerous entities or locations. DLT has already succeeded in the financial technology industry.

Blockchain use cases, such as the one described, reveal the following benefits of blockchain technology:

- Decentralized management

- Indisputable audit trail
- Data trusted, transparent, and easily tracked
- Robustness and availability
- Privacy and security

Threats to Security

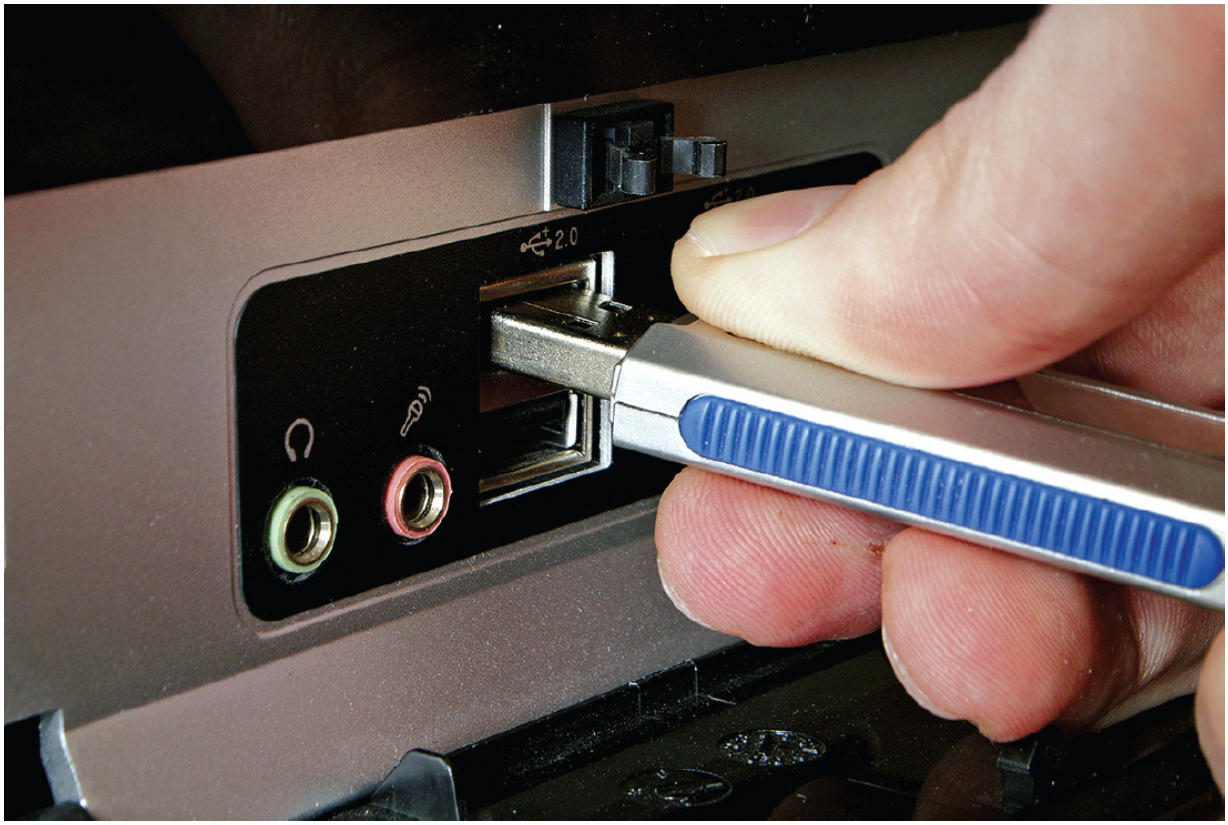
The largest benefit of a computer network is the ability to share information. However, organizations need to protect that information and ensure that only authorized individuals have access to the network and the data appropriate to their role. Threats to data security in healthcare organizations are becoming increasingly prevalent. A nationwide survey by the Computing Technology Industry Association (CompTIA) found that human error was responsible for more than half of security breaches. Human error was categorized as failure to follow policies and procedures, with more than half of the organizations believing that their employees ignore their cybersecurity guidelines, are generally careless, lack experience with websites and applications, and are unaware of new threats (Greenberg, 2015; O'Driscoll, 2023). The literature continues to abound with information concerning the snowballing volume of electronic patient data that is vulnerable and the frequency and types of compliance complaints and data breaches such as hacking, loss, improper handling, and theft (Alder, 2021; American Hospital Association, 2023b; Culbertson, 2021; DeGaspari, 2010; Health Information and Management Systems Society [HIMSS], 2019).

In the *Fifth Annual Benchmark Study on Privacy and Security of Healthcare Data*, the Ponemon Institute (2015) reported that "[m]ore than 90 percent of healthcare organizations represented in this study had a data breach, and 40 percent had more than five data breaches over the past two years" (para. 3). Interestingly, the most common type of data breach was related to a criminal attack on the healthcare organization (up 125% over the past 5 years). Key terms related to criminal attacks are **brute force attack** (i.e., software used to guess network passwords) and **zero day attack** (i.e., searching for and exploiting software vulnerabilities). Of the intentional data breaches (as opposed to unintentional), "45 percent of healthcare organizations say the root cause of the data breach was a criminal attack and 12 percent say it was due to a malicious

insider" (Ponemon Institute, 2015, para. 4). That leaves nearly 43% of data breaches in the unintentional category. Alder (2015) reported on the HIMSS 2015 Healthcare Cybersecurity Survey, which determined the **negligent insider** to be the most common source of a **security breach**. Examples of unintentional, or negligent, breaches include lost or stolen devices and walking away from a workstation without logging off, both of which could be cause for discipline or even dismissal from a job. An interesting example of an unintentional data breach was reported on the Office for Civil Rights website. A company leased photocopier equipment and returned it without erasing the healthcare data stored on the copier's hard drive, which resulted in a settlement of over $1.2 million (U.S. Department of Health and Human Services [HHS], 2017). The findings of the 2019 HIMSS Cybersecurity Survey suggested that "healthcare cybersecurity practices are moving in the right direction with some degree of uniformity. The findings also suggest there is room for improvement" (p. 20). Alder (2020) stated that "2019 was a particularly bad year for healthcare data breaches with 510 data breaches reported by HIPAA-covered entities and their business associates. That equates to a rate of 42.5 data breaches per month" (para. 2). There was a major increase in hacking and IT incident breaches: "[M]ore than 59% of data breaches reported to the HHS' Office for Civil Rights were the result of hacking, malware, ransomware, phishing attacks, and other IT security breaches" (Alder, 2020, para. 4). According to Alder (2021), "Across the 686 2021 healthcare data breaches, 44,993,618 healthcare records have been exposed or stolen, which makes 2021 the second-worst year in terms of breached healthcare records" (para. 3). The worst year thus far has been 2020 (Kath, 2021). We are improving but must maintain and increase our efforts. Recurring security training for employees can help reduce the risks associated with phishing attacks, and healthcare organizations must be proactive in anticipating the potential for and preventing security breaches.

The first line of defense is strictly physical. A locked office door, an operating system that locks down after 5 minutes of inactivity, and regular security training programs are extremely effective in this

regard. Proper workspace security discipline is a critical aspect of maintaining security. Employees need to be properly trained to be aware of computer monitor visibility, shoulder surfing, and policy regarding the removal of computer hardware. A major issue facing organizations is removable storage devices (**Figure 12-2**). **Jump drives**, **flash drives**, and **thumb drives** (which use USB port access) are potential security risks. These devices can be slipped into a pocket and therefore easily removed from the organization. One way to address this physical security risk is to limit the authorization to write files to a device. Organizations are also turning off the USB ports on company desktops.



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Figure 12-2 A Removable Storage Device

The most common security threats a corporate network faces are hackers, malicious codes (i.e., spyware, adware, ransomware,

viruses, **worms**, and **Trojan horses**), and malicious insiders. Acceptable use policies help to address these problems. For example, employees may be restricted from downloading files from the internet. Downloaded files, including email attachments, are the most common way viruses and other malicious codes enter a computer network. Typically, network security policies prohibit employees from using personal USB drives, thereby preventing the transfer of malicious codes from a personal computer to the network.

Let's look more closely at some of these common network security threats. Typically, we think of **hackers** as outsiders who attempt to break into a network by exploiting software and network vulnerabilities, and indeed these black hat (i.e., malicious) hackers (also called crackers) do exist. However, more organizations are looking to employ ethical hackers (i.e., white hat hackers), who are the hackers skilled at looking for and closing network security vulnerabilities (Caldwell, 2011; Milijkovac, 2022).

Spyware and adware are normally controlled in a corporate network by limiting the functions of the browsers used to surf the internet. For example, browser privacy options can control how cookies are used. A cookie is a very small file written to the hard drive of a computer whose user is surfing the internet. This file contains information about the user. For example, many shopping sites write cookies to the user's hard drive containing the user's name and preferences. When that user returns to the site, the site will greet them by name and list products in which they are possibly interested. Weather websites send cookies to users' hard drives with their ZIP code so that when a user returns to that site, the local weather forecast is immediately displayed. On the negative side, cookies can follow the user's travels on the internet. Marketing companies use spying cookies to track popular websites that could provide a return on advertising expenditures. Spying cookies related to marketing typically do not track keystrokes in an attempt to steal user IDs and passwords; instead, they simply track which websites are popular, and these data are then used to develop advertising and marketing strategies. Nurse informaticists exploring new healthcare

technologies on the internet may find that ads for these technologies begin to pop up the next few times they are on the internet. Spyware that does steal user IDs and passwords contains malicious code that is normally hidden in a seemingly innocent file download. This threat to security explains why healthcare organizations typically do not allow employees to download files. The rule of thumb to protect the network and one's own computer system is to download files only from a reputable site that provides complete contact information. Be aware that sometimes malicious code is hidden in an email link or in a file sent by a trusted contact whose email has been hacked. If you are not expecting a file from an email contact or if you receive an email with only a link in it, resist the urge to download or click.

A relatively new threat to healthcare organizations is **ransomware**, which is malicious code that blocks the organization from using its computer systems until a ransom is paid to the hacker. Business Wire (2021) suggested that healthcare delivery systems must pay attention to the Ponemon Institute's research concerning ransomware and transform their current cybersecurity practices. The American Hospital Association (2023a) reported that the FBI "seized control of servers and websites used by the Hive ransomware network to target hospitals and other critical infrastructure, and infiltrated the network in July to provide decryption keys to victims and prevent $130 million in ransom payments" (para. 1). Consider the following cases of ransomware intrusion from 2016 and 2020. Waddell (2016) described a hospital in Los Angeles that operated without access to its electronic health records for several weeks when hackers took over its computer systems and then demanded $3.6 million in bitcoin cryptocurrency ransom to return access of the computer system to the hospital. Cryptocurrencies provide anonymity to the hackers. The hackers were able to encrypt the patient records, which meant even though they might not have gained access to the files, the real goal was not to access the content of these records but instead to hold them hostage so that the hospital could not access them. This ransom was made possible due to ransomware, which is viruses and malware unleashed to take

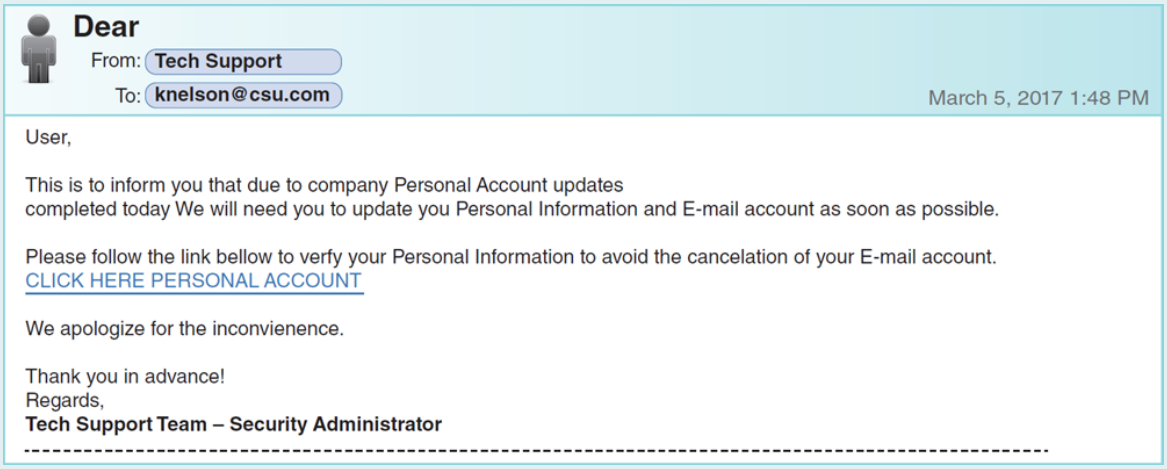
over a server or computer by encrypting the files so that hackers can demand money to return control to the rightful owners. With the expanding use of networked devices and servers, hackers are leveraging ransomware attacks because businesses must have access to their data. Such attacks continue to affect healthcare organizations and have even interfered with clinical trials. Perlroth (2020) reported on October 3, 2020, that in the past 2 weeks, a company that "sells software used in hundreds of clinical trials, including the crash effort to develop tests, treatments and a vaccine for the coronavirus, was hit by a ransomware attack that has slowed some of those trials" (para. 1). These attacks can be devastating and far-reaching; this company's software is being used in pharmaceutical trials conducted throughout Europe, Asia, and North America.

In addition to strict policies related to network security, organizations may also use software or hardware tools, such as firewalls (covered in the next section) and **intrusion detection devices**, to protect from hackers. Protect yourself at home by ensuring that you have an updated version of **antivirus software**, be wary of unusual emails, and develop strong passwords and change them frequently. If your email is hacked, report it to the proper authorities as soon as possible, warn your contacts that you have been hacked, change your password, and check to see that your antivirus software is up to date.

Another huge threat to corporate security is **social engineering**, which is the manipulation of a relationship based on one's position (or pretend position) in an organization. For example, someone attempting to access a network might pretend to be an employee from the corporate IT office who simply asks for an employee's user ID and password. The outsider can then gain access to the corporate network. Once this access has been obtained, all corporate information is at risk. A second example of social engineering is a hacker impersonating a federal government agent. After talking an employee into revealing network information, the hacker has an open door to enter the corporate network. A related type of social engineering is **phishing**, which is an attempt to steal

information by manipulating the recipient of an email or phone call to provide passwords or other private information. **Box 12-2** contains an example of a phishing email and tips for identifying phishing scams.

BOX 12-2 IDENTIFYING PHISHING SCAMS



Dear

From: Tech Support

To: knelson@csu.com

March 5, 2017 1:48 PM

User,

This is to inform you that due to company Personal Account updates
completed today We will need you to update you Personal Information and E-mail account as soon as possible.

Please follow the link bellow to verfy your Personal Information to avoid the cancelation of your E-mail account.
CLICK HERE PERSONAL ACCOUNT

We apologize for the inconvienence.

Thank you in advance!
Regards,
Tech Support Team – Security Administrator

Description

EXAMPLE OF A PHISHING SCAM EMAIL

Check suspicious emails for grammar and spelling errors, generic greetings (e.g., User, Dear, or Dearest), or requests for immediate action or personal information (e.g., passwords or bank account numbers). Some phishing emails may appear to come from your bank or another trusted organization. Think carefully about why a seemingly legitimate organization might be asking for information it should already have or why it might need to know what it is asking for. Be aware of your organization's procedures for reporting phishing scams, and do so immediately.

Data from: Pennsylvania State University, Office of Information Security. (n.d.). *What is phishing?* http://phishing.psu.edu/what-is-phishing

Additional types of social engineering schemes include **spear phishing**, which is a more specifically targeted scheme whereby the attacker takes advantage of contact information provided in an organization's directory and tailors the scam email to a specific

person; **baiting**, which is when a malware-infected USB flash drive is left in a public area, thus tricking the finder into loading it to identify its owner; and **scareware**, which is when the scam email reports that the user has been hacked and tricks them into giving the hacker remote access to the computer to "fix" it (Rosencrance, n.d.).

Another example of an important security threat to a corporate network is the **malicious insider**. This person can be a disgruntled or recently fired employee whose rights of access to the corporate network have not yet been removed. In the case of a recently fired employee, their network access should be suspended immediately upon notice of termination. To avoid the potentially hazardous issues created by malicious insiders, healthcare organizations need a policy and specific procedures to monitor employee activity to ensure that employees carry out only those duties that are part of their normal job. Separation of privileges is a common security tool, which means that no single employee should be able to complete a task that could cause a critical event without the knowledge of another employee. For example, the employee who processes and prints the checks should not be the same employee who signs those checks. Similarly, the employee who alters pay rates and hours worked should be required to submit a weekly report to a supervisor before the changes take effect.

Software that can track and monitor employee activity is also available. This software can log which files an employee accesses and whether changes were made to the files or the files were copied. Depending on the number of employees, organizations may also employ a full-time electronic auditor who does nothing but monitor activity logs and hire full-time employees to provide network security. The amount of money allocated varied greatly, but "over one-quarter of respondents (26%) operate within a system that spends money on cybersecurity activities/resources, even though there is no specific cybersecurity 'carve out' within the IT budget" (HIMSS, 2019, p. 9). Additional strategies for securing networks that were suggested in this HIMSS survey were mock cyber defense exercises, sharing information between and among healthcare

organizations, monitoring vendor intelligence feeds, and subscribing to security alerts and tips from the United States Computer Emergency Readiness Team (www.cisa.gov).

Security Tools

A wide range of tools is available to an organization to protect the organizational network and information. Software Testing Help (2023) provides cybersecurity testing tools for mobile devices to the web, including antivirus technology, firewalls, and data encryption being used in health care. These tools can be either a software solution, such as antivirus software, or a hardware tool, such as a **proxy server**. Such tools are effective only if they are used along with employee awareness training.

For example, email scanning is a commonly used software tool. All incoming email messages are scanned to ensure that they do not contain a virus or some other malicious code. This software can find only viruses that are currently known, so it is important that the virus software be set to search for and download updates automatically. Organizations can further protect themselves by training employees to never open an email attachment unless they are expecting the attachment and know the sender. Even IT managers have fallen victim to email viruses that sent infected emails to everyone in their address book. Employees should be taught to protect their organization from new viruses that may not yet be included in their scanning software by never opening an email attachment unless the sender is known and the attachment is expected. Email scanning and antivirus software should never be turned off, and updates should be installed at least weekly or, ideally, daily. Software is also available to scan instant messages and automatically delete spam email.

Many antivirus and adware software packages are available for fees ranging from free to more than $25 per month (for personal use) to several thousands of dollars per month (to secure an organization's network). The main factors to consider when purchasing antivirus software are its effectiveness (i.e., the number of viruses it has missed), the ease of installation and use, the effectiveness of the updates, and the help and user support

available. Numerous websites compare and contrast the most recent antivirus software packages. Be aware, however, that some of these sites also sell antivirus software, so they may present biased information.

Firewalls are another tool used by organizations to protect their corporate networks when they are connected to the internet. A **firewall** can be hardware or software or a combination of both and is used to examine all incoming messages or traffic to the network. The firewall can be set up to allow only messages from known senders into the corporate network and look at outgoing information from the corporate network. If the message contains some type of corporate secret, the firewall may prevent the message from leaving. In essence, firewalls serve as electronic security guards at the gate of the corporate network.

Proxy servers also protect the organizational network by preventing users from directly accessing the internet. Instead, users must first request passage from the proxy server. The server looks at the request and makes sure that the request is from a legitimate user and that the destination of the request is permissible. For example, organizations can block requests to view a website with the word *sex* in the title or the actual uniform resource locator of a known pornography site. The proxy server can also lend the requesting user a **mask** to use while they are surfing the web, which allows the corporation to protect the identity of its employees. The proxy server keeps track of which employees are using which masks and directs the traffic appropriately.

With hacking becoming more common, healthcare organizations must have some type of protection to avoid this invasion. An **intrusion detection system** (both hardware and software) allows an organization to monitor who is using the network and which files that user has accessed. Detection systems can be set up to monitor a single computer or an entire network. Corporations must diligently monitor unauthorized access of their networks. Anytime someone uses a secured network, a digital footprint of all the user's travels is left, which can be easily tracked by electronic auditing software.

Everyone in nursing informatics and IT has a tremendous amount of work to do and must be forever vigilant to maintain the highest level of cybersecurity. Healthcare organizations have taken many positive steps since the 2015 HIMSS survey, which is reflected in the 2019 survey. In 2019, 44% of the respondents agreed and 15% strongly agreed that "[c]ybersecurity professionals feel empowered to drive change in healthcare organizations" (HIMSS, 2019, p. 8). The 2021 HIMSS Cybersecurity Survey reflected that "most respondents (59%) reported an increase in cybersecurity budgets for 2022. It is likely that this increase in budgets will lead to more positive growth within healthcare cybersecurity programs" (HIMSS, 2022, p. 15).

Off-Site Use of Portable Devices

Off-site use of portable devices, such as laptops, tablets, home computing systems, smartphones, smart devices, and portable data storage devices, can help to streamline the delivery of health care. For example, home health nurses may need to access **electronic protected health information (EPHI)** via a wireless laptop connection during a home visit, or a physician might use a smartphone to get specific patient information related to a prescription refill in response to a patient request. These mobile devices are invaluable to healthcare efficiency and responsiveness to patient need in such cases. At the very least, however, agencies should require data encryption when EPHI is being transmitted over unsecured networks or transported on a mobile device as a way of protecting sensitive information. Hotspots provided by businesses, such as coffee shops or restaurants and airports, are not secured networks. Virtual private networks (VPNs) must be used to ensure that all data transmitted on unsecured networks are encrypted. The user must log in to the VPN to reach the organization's network.

Only data essential for the job should be maintained on a mobile device; other nonclinical information, such as Social Security numbers, should never be carried outside the secure network. Some institutions make use of thin clients, which are basic interface portals that do not keep **secure information** stored on them. Essentially, users must log in to the network to get the data they need. Use of thin clients may be problematic in patient-care situations where the user cannot access the network easily. For example, some rural areas of the United States do not have wireless or cellular data coverage. In these instances, private health information may need to be stored in a clinician's laptop or tablet. This is comparable to home health nurses carrying paper charts in their cars to make home visits and entails the same responsibilities that accompany such use of private information outside the institution's walls.

What happens if one of these devices is lost or stolen? The agency is ultimately responsible for the integrity of the data contained on these devices and is required by HIPAA regulations (HHS, 2006) to have policies in place covering such items as appropriate remote use, removal of devices from their usual physical location, and protection of these devices from loss or theft. Simple rules, such as covering laptops left in a car and locking car doors during the transport of mobile devices containing EPHI, can help to deter theft. If a device is lost or stolen, the agency must have clear procedures in place to help ensure that sensitive data are not released or used inappropriately. Software packages that provide for physical tracking of the static and mobile computer inventory, including laptops, smartphones, and tablets, are being used more widely and can assist in the recovery of lost or stolen devices. In addition, some software that allows for remote data deletion (data wipe) in the event of theft or loss of a mobile device can be invaluable to the agency in preventing the release of EPHI.

If a member of an agency is caught accessing EPHI inappropriately or stealing a mobile device, the sanctions should be swift and public. Sanctions may range from a warning or suspension with retraining to termination or prosecution, depending on the severity of the security breach. The sanctions must send a clear message to everyone that protecting EPHI is serious business. The following strategies for managing remote access are imperative:

- Remote access must be restricted to company-owned and company-configured computers and devices.
- Strong VPN policies must be in place and enforced, including the creation of a safe space or sandbox that isolates or quarantines the session from other software running on the remote device.
- User privileges associated with remote access must be stringently applied and enforced based on company policy.
- Effective educational programming must be instituted and mandated for all personnel to ensure safe computing practices associated with remote locations and remote access. Updates

and retraining must be provided at specified intervals to maintain safe remote access practices.

To protect patients and their data, nurses must consider the effect of wireless mobile devices (see **Box 12-3**). Data can be stolen by an employee very easily through the use of email or file transfers.

BOX 12-3 POKÉMON TARGETS HOSPITAL

Informatics nurse specialists must be aware of the uses of portable devices. In 2016, this came to light when one hospital in the Pittsburgh area was a site of a popular game and the administration was upset because it created a privacy issue for people using their hospital as a search site. This hospital contacted the game developer to be removed from its game.

Hospitals must always be concerned about privacy and safety issues within their control but also be on the alert for those outside their control, such as the Pokémon Go game. Marcie Cipriani, with *Pittsburgh's Action News 4*, reported that Pokémon Go used West Penn Hospital, which is part of the Allegheny Health Network in Pittsburgh, as a real-world location in the game. The game utilizes enhanced reality, which allows players to combine images from the real world with those of the game. The Allegheny Health Network officials stated that the exciting, interactive game created concerns when it brought players inside their hospital. They say hunting Pokémon at the hospital created a patient privacy issue and a safety concern. Administrators warned those who were playing to stay out of their hospitals, and they contacted the game's developer, who agreed to remove their hospitals from the app. They asked their employees to be on the lookout for anyone playing the app while they were walking around the hospital and to contact security if they saw Pokémon Go players.

Data from: Cipriani, M. (2016, July 29). Pokemon 'Gone:' Players banned from Allegheny Health Network facilities. *Pittsburgh's Action News 4*. www.wtae.com/article/pokemon-gone-players-banned-from-allegheny-health-network-facilities-1/7481333

Malware, or malicious code, that infiltrates a network can collect easily accessible data. One of the evolving issues is lost or stolen devices that can provide a gateway into a healthcare organization's

network and records. When the device is owned by the employee, other issues arise as to how the device is used and secured.

The increase in cloud computing has also challenged healthcare professionals' personal and professional security and privacy. **Cloud computing** refers to storing and accessing data and computer programs on the internet rather than on the local hard drive of a computer. Common examples of cloud computing for personal use include Google Drive, Apple iCloud, and Amazon. Cloud computing allows for easy syncing of separate devices to promote sharing and collaboration (Griffith, 2022). According to Jansen and Grance (2011), cloud computing "promises to have far-reaching effects on the systems and networks of federal agencies and other organizations. Many of the features that make cloud computing attractive, however, can also be at odds with traditional security models and controls" (p. vi). Healthcare organizations moved to the cloud because cloud computing tends to be cheaper and faster, offers more flexibility for work location, provides nearly immediate disaster recovery, supports collaboration, provides security, and offers frequent software updates (Salesforce UK, 2020). However, there are important security concerns related to cloud computing in health care. To maintain security in a cloud environment, several safeguards must be in place, such as encoding files with encryption at both the local and the cloud levels, adding multiple access controls such as multifaceted authentication methods, and providing **data loss prevention (DLP)** protocols and tools. The threats continue. According to Accenture (n.d.), "digitalization and the Cloud Continuum have redefined not only enterprise boundaries and capabilities but also the attack surface, adding vulnerabilities that are beyond the reach of traditional responses" (para. 2). Therefore, data must be guarded as more and more functions are moved to the cloud. One way to do this is through the DLP strategy. This approach is critical for making sure that end users do not send sensitive or critical information outside the institution's network. The **virtual desktop interface (VDI)** allows the user to have a computer for which the operating system, applications, and data are located and accessed on a central server instead of on the local desktop. Many

VDIs are cloud based, meaning a complete desktop and app virtualization service runs in the cloud. Desktops can have security issues, but with the VDI, the IT team can generate and delete virtual desktops instantly. On the flip side, the cloud must then be secured.

It is clear that healthcare organizations need to be extra vigilant about their data security when using cloud computing. However, as we emphasized several times in this chapter, employee training on security measures may be the most important defense. Many security strategies are focusing on employees or threats from within since careless or negligent employees are still considered a major risk to the healthcare organization (Ekran, 2023; Guccione, 2015; Schwartz, 2022).

Summary

Technology changes so quickly that even the most diligent user will likely encounter a situation that could constitute a threat to their network. Organizations must provide their users with the proper training to help them avoid known threats and, more importantly, be able to discern a possible new threat. Consider that 10 years ago wireless networks were the exception to the rule, whereas today access to wireless networks is almost taken for granted. How will computer networks be accessed 10 years from now? The most important concept to remember from this chapter is that the only completely safe network is one that is turned off. **Network accessibility** and **network availability** are necessary evils that pose security risks. The information must be available to be accessed, yet it must remain secured from hackers, unauthorized users, and any other potential security breaches. As the cloud expands, so do the concerns over security and privacy. The major threat remains from insiders or employees being negligent or malicious. In an ideal world, everyone would understand the potential threats to network security and diligently monitor and implement tools to prevent unauthorized access of their networks, data, and information.

THOUGHT-PROVOKING QUESTIONS

1. Sue is a chronic obstructive pulmonary disorder clinic nurse enrolled in a master's education program. She is interested in writing a paper on the factors that are associated with poor compliance with medical regimens and associated repeat hospitalization of chronic obstructive pulmonary disorder patients. She downloads patient information from the clinic database to a thumb drive that she later accesses on her home computer. Sue understands rules about privacy of information and believes that because she is a nurse and needs this information for a graduate school

assignment, she is entitled to the information. Is Sue correct in her thinking? Describe why she is or is not correct.

2. The nursing education department of a large hospital system has been centralized; as a consequence, the nurse educators are no longer assigned to one hospital but must now travel among all the hospitals. They use their smartphones to interact and share data and information. What are the first steps you would take to secure these transactions? Describe why each step is necessary.
3. Research cloud computing in relation to health care. What are the major security and privacy challenges? Please choose three and describe them in detail.
4. Blockchain is touted as a security measure. Describe in detail how blockchain technology functions and why it would help maintain security.
5. How can organizations decrease negligence among their employees? State two detailed ways to prevent breaches caused by careless employees.

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CHAPTER 13

Achieving Excellence by Managing Workflow and Initiating Quality Projects

OBJECTIVES

1. Provide an overview of the purpose of conducting workflow analysis and design.
2. Deliver specific instructions on workflow analysis and redesign techniques.
3. Cite measures of efficiency and effectiveness that can be applied to redesign efforts.
4. Explore quality improvement processes.

KEY TERMS

- Alternative Payment Model (APM)
- American Recovery and Reinvestment Act (ARRA)
- barcode medication administration
- clinical transformation
- computerized provider order entry (CPOE)
- electronic health record (EHR)
- event
- health information exchange (HIE)
- health information technology
- information system
- interaction

- Lean
- meaningful use
- medical home model
- Medicare Access and CHIP Reauthorization Act of 2015 (MACRA)
- Merit-based Incentive Payment System (MIPS)
- metrics
- Patient Room 'Next' (PRN)
- process analysis
- process map
- process owner
- Qualified Clinical Data Registry
- quality
- quality improvement (QI)
- Quality Payment Program
- Six Sigma
- task
- work process
- workflow
- workflow analysis

Introduction

The healthcare environment has grown more complex over the years and continues to evolve every day. Unfortunately, the complexities that help clinicians deliver better care and improve patient outcomes also take a toll on the clinicians themselves. This toll is exemplified through hours spent learning new technology, loss in productivity as users adjust and adapt to new technology, and unintended **workflow** consequences from the use of technology.

Despite the perceived negative downstream effects to end users and patients as a result of technology, this very same technology can improve efficiency and yield a leaner healthcare environment. The intent of this chapter is to outline the driving forces that create the need to manage or redesign workflow as well as elucidate what the nurse must know about how to conduct workflow redesign, measure the effect of workflow changes, and promote the best use of technology.

Purpose of Workflow Analysis

According to The Patient Safety League (2023), "2.2 million patients are harmed by medical errors every day in this country and 440,000 of them DIE from PREVENTABLE medical errors daily."

Not only is there an effect on patients and their families from these errors but also there is a significant financial effect on healthcare organizations. Clearly, we must minimize these errors, and one of the most important tools for this purpose is the use of electronic health records and **information systems** to improve communication and provide point-of-care decision support and automation.

Technology can provide a mechanism to improve care delivery and create a safer patient environment provided it is implemented appropriately and considers the effect on the surrounding workflow. In an important early article, Campbell et al. (2009) suggested that technology implemented without consideration of user workflow can create greater patient safety concerns than no technology at all. Consideration of **computerized provider order entry (CPOE)**, for example, helps us to focus more specifically on workflow effects. Sometimes these negative workflow implications are referred to as the unintended consequences of CPOE implementation and were likely due to poorly implemented technology. Ash et al. (2009) reported on nine unintended consequences of CPOE. Interestingly, a later study by Abraham et al. (2018) also reported on workflow process issues with CPOE, and they identified four core categories: order entry issues, user issues, system limitations, and care transition issues.

The Healthcare Information Management Systems Society Toolkit addressed workflow redesign and considered why it is so critical to successful technology implementations. Replacing or upgrading a system that was already automated requires substantially less workflow redesign than implementing an information technology (IT) system that addresses a process that was not previously automated.

The toolkit was instrumental in identifying and describing several workflow improvement theories. These theories and others are still used today: total quality management (TQM), business process reengineering (BPR), plan-do-check-act (PDCA), **Six Sigma**, **Lean** and Lean Six Sigma, business process management (BPM), and five whys analysis (Laoyan, 2023). Consistently and rigorously using these theories helps support process improvements in an organization by providing well-defined processes and improved workflows. Reflect on the addition of machine learning and artificial intelligence (AI) (Health Catalyst, 2021; Hopkins, 2019). For more information about each of these processes, review the information provided in the cited references, or search for each one individually.

Nursing informaticists are invaluable for successful system implementation by defining clinical workflow, enhancing efficiencies, improving **quality**, and acting as change agents to promote adoption (Schoenbaum & Carroll, 2021). Thompson et al. (2016) stated that "[b]y partnering clinicians with informaticists we strove to leverage the power of the electronic medical record (EMR) to reduce heart failure readmissions and improve patient transitions back to the community" (p. 380). They concluded that "[p]artnering with clinical informatics enabled the multidisciplinary team to leverage the power of the EMR in supporting and tracking new clinical workflows that impact patient outcomes" (p. 380). This multidisciplinary team believed that its success could reshape how healthcare providers facilitate patient discharge and the transition home. Leveraging the multidisciplinary team and the EMR could provide a model for patient-centered and cost-effective care that could extend beyond its patients with heart failure.

Technology is recognized to have a potentially positive effect on patient outcomes. Nevertheless, even with the promise of improving how care is delivered, adoption of technology was slow. The cost of technology solutions, such as CPOE, **barcode medication administration**, and **electronic health records (EHRs)**, was one of the main reasons for initial resistance. The cost of technology, coupled with the lengthy timelines required to develop and implement such technology, initially put this endeavor out of reach

for many healthcare organizations. In addition, upgrades to the technology are often necessary either during the implementation or shortly after a launch, leaving little time to focus efforts on the optimization of the technology within the current workflow. Furthermore, the existence of technology does not in itself guarantee that it will be used in a manner that promotes better outcomes for patients.

Given the sluggish adoption of technology, in 2009 the U.S. government took an unprecedented step when it formally recognized the importance of **health information technology** for patient care outcomes. As a result of the provisions of the **American Recovery and Reinvestment Act (ARRA)**, healthcare organizations were able to qualify for financial incentives based on the level of meaningful use achieved. **Meaningful use** referred to the rules and regulations established by the ARRA. The three stages of meaningful use were part of an EHR incentive program, renamed in 2018 to Promoting Interoperability Programs (Centers for Medicare and Medicaid Services [CMS], 2022). During stage 1, the focus was on data capturing and sharing. Stage 2 focused on advanced clinical processes, and stage 3 sought to improve outcomes. Stage 1 was initiated from 2011 to 2012, stage 2 began in 2014, and stage 3 was established in 2017 (CMS, 2021). However, with the new goal of paying for value and better care, the **Medicare Access and CHIP Reauthorization Act of 2015 (MACRA)** reformed Medicare payments by making changes that created the **Quality Payment Program** to replace the hodgepodge system of Medicare reporting programs (CMS, 2016b; see **Figure 13-1**). The MACRA Quality Payment Program has two paths—**Merit-based Incentive Payment System (MIPS)** or **Alternative Payment Model (APM)**—which will be in effect through 2021 and beyond (CMS, 2016b). The MACRA requirements for the Measure Development Plan follow:

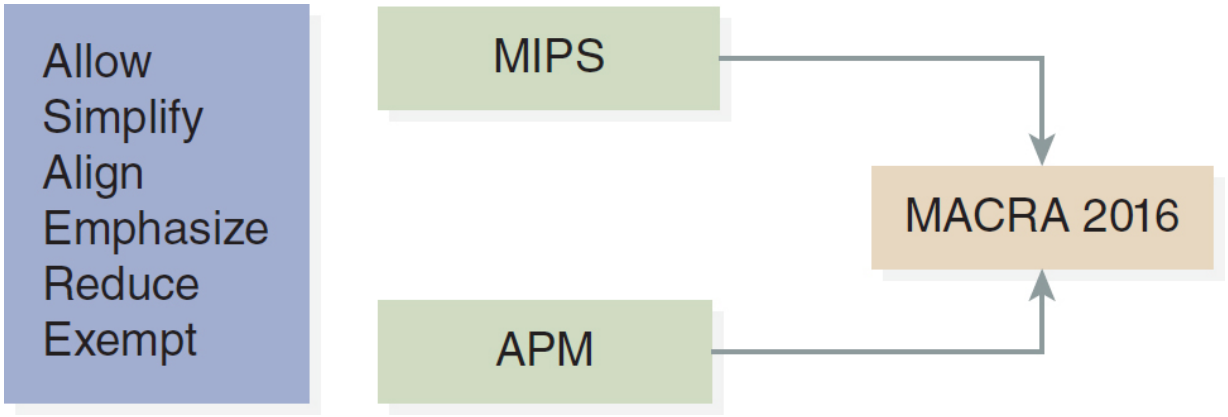


Figure 13-1 MACRA

- Multipayer applicability
- Coordination and sharing across measure developers
- Clinical practice guidelines
- Evidence base for nonendorsed measures
- Gap analysis
- Quality domains and priorities
- Applicability of measures across healthcare settings
- Clinical practice improvement activities
- Considerations for electronic specifications and **Qualified Clinical Data Registries** (QCDRs) (CMS, 2016a, p. 16)

For an organization seeking to meet these measures, the data to support these measures must be gathered and reported on electronically, which necessitates the use of technology in all patient care areas. The successful implementation of the Measurement Development Plan "depends on a successful partnership with patients, frontline clinicians, and professional organizations and collaboration with other diverse stakeholders to develop measures that are meaningful to patients and clinicians and can be used across payers and health care settings" (CMS, 2016a, p. 64). Many of the quality reporting measures rely on nursing and medical documentation. Most healthcare personnel already use EHRs, but MACRA measures pushed healthcare organizations to reexamine the

use of clinical technologies within their organizations and approach implementation in a new way.

Not only is there a potential for patient safety and quality issues to arise from technology implementation that does not address workflow, but a financial impact on the organization is possible as well. We must make sure that technology is not a barrier to quality healthcare and patient safety (American Society for Health Care Risk Management [ASHRM], 2021). All organizations, regardless of their industry, must operate efficiently to maintain profits and continue to provide services to their customers. For hospitals, which normally have significantly smaller profit margins than other organizations, the need to maintain efficient and effective care is essential for survival. Given that hospital profit margins are diminishing, never has there been a more crucial time than now to examine the costs of errors and poorly designed workflows and the financial burden they present to an organization. Moreover, what are the costs to an organization that fails to address the appropriate integration of technology? This is an area for which few supporting data exist to substantiate the claim that technology without workflow considerations can, in fact, affect the bottom line.

Many healthcare organizations have or are still experiencing the effects of poorly implemented clinical technology solutions. These effects may be manifested in the form of redundant documentation, non–value-added steps, and additional time spent at the computer rather than in direct care delivery. Consider these post-implementation examples of workflow issues. Gugerty et al. (2007) studied the challenges and opportunities in nursing documentation and determined that it was possible to decrease by 25% per shift the time a nurse spends documenting. Technology ought not to be implemented for the sake of automation unless it promises to deliver gains in patient outcomes and proper workflow. In fact, the cost to organizations for duplicate/redundant documentation by nursing can range from $6,500 to $13,000 per nurse per year (Clancy et al., 2006). Stokowski (2013) found other issues, such as systems that are slow and freeze; lose data; and "don't dump data from monitors and screening devices into the EHR in real time," which slows the

documentation process and increases the amount of time the nurse must spend on the computer and not in direct patient care (p. 9). Cision PR Newswire (2018) reported on a Black Book Market Research survey that 96% of nurse survey respondents are largely satisfied with EHR documentation and 83% appreciated the quick responses by IT departments to reported issues. On a positive note, "[e]ighty-five percent of nurses now see competency with at least one EHR as a highly-sought employment skill for an RN, and sixty-five percent believe nurses with multiple fluencies are deemed a highly superior job candidate currently by health systems" (para. 9). However, there are still some challenges negatively affecting workflow because computers or handheld devices are not in every room.

Examining the workflow surrounding the use of technology enables better use of the technology and more efficient work. It also promotes safer patient care delivery. The need to focus on workflow and technology is attracting increasing recognition, although a dearth of literature remains that addresses the importance of this area. As more organizations work to achieve a level of technology adoption that will enable them to meet MACRA measures and receive financial payments, more attention will be paid to the area of workflow design, resulting in a greater body of research and evidence (Agency for Healthcare Research and Quality [AHRQ], n.d.; Yuan et al., 2013).

Workflow and Technology

Workflow is a term used to describe the action or execution of a series of **tasks** in a prescribed sequence. Another definition of *workflow* is a progression of steps (i.e., tasks, **events**, or **interactions**) that constitute a **work process**, involve two or more persons, and create or add value to the organization's activities. In a sequential workflow, each step depends on the occurrence of the previous step; in a parallel workflow, two or more steps can occur concurrently. Sometimes the term *workflow* is used interchangeably with *process* or *process flows*, particularly in the context of implementations. Observation and documentation of workflow to better understand what is happening in the current environment and how it can be altered is referred to as **workflow analysis**. A typical output of workflow analysis is a visual depiction of the process, called a **process map**. The process map ranges from simplistic to fairly complex and provides an excellent tool for identifying specific steps. It can also provide a vehicle for communication and a tool upon which to build educational materials as well as policies and procedures.

One school of thought suggests that technology should be designed to meet the needs of clinical workflow (Yuan et al., 2013). This model implies that system analysts have a high degree of control over screen layout and data capture. It also implies that technology is malleable enough to allow for the flexibility to adapt to a variety of workflow scenarios. Lessons learned from more than three decades of clinical technology implementations suggest that clinical technologies still have a long way to go on the road to maturity to allow this to be possible. The second and probably most prevalent thought process is that workflow should be adapted to the use of technology. Today, this is by far the most commonly used model given the progress of clinical technology. Bucur et al. (2016) developed clinical models to support clinical decision-making that were inserted into the workflow models. This system integrates a

workflow suite and functionality for the storage, management, and execution of clinical workflows and the storage of traces of execution. The knowledge models are integrated and run from the workflow to support decisions at the right point in the clinical process (Bucur et al., 2016, p. 152). The ability to track and assess decision-making throughout a clinical course of care for a patient will enhance nursing knowledge and improve patient care. Flohr et al. (2018) described a design process for a mobile application that would combine outputs from multiple pieces of intensive care unit equipment to aid clinicians in assessing, processing, and clinical decision-making. Their approach included 54 hours of clinical observations as well as stakeholder interviews. In this way, workflow informed the technology design rather than the technology driving the consequent workflow.

A concept that has gained popularity in recent years relative to workflow redesign is clinical transformation. **Clinical transformation** is the complete alteration of the clinical environment; therefore, this term should be used cautiously to describe redesign efforts. Earl et al. (1995) defined transformation as "a radical change approach that produces a more responsive organization that is more capable of performing in unstable and changing environments that organizations continue to be faced with" (p. 31). Many workflow redesign efforts are focused on relatively small changes and not on the widespread change that accompanies transformational activities. Moreover, clinical transformation would imply that the manner in which work is carried out and the outcomes achieved are completely different from the prior state, which is not always true when the change simply involves implementing technology. Technology can be used to launch or in conjunction with a clinical transformation initiative, although the implementation of technology alone is not perceived as transformational.

Before undertaking transformative initiatives, the following guidelines should be understood:

- Leadership must take the lead and create a case for transformation.
- Establish a vision for the end point.
- Allow those persons with specific expertise to provide the details.
- Think about the most optimal experience for both the patient and the clinician.
- Do not replicate the current state.
- Focus on those initiatives that offer the greatest value to the organization.
- Recognize that small gains have no real impact on transformation.

Holston (2022) reported on **Patient Room 'Next' (PRN)**, which is an approach to provide high-quality health care to patients wherever they are located. The patient could be in the community, their home, or even an ambulance. The PRN strategy looks to the future of technology and patient care in five key categories: "machine vision, machine audio, content interaction with patients, sensors and telehealth" (para. 3). There is a need to improve patient care and clinical workflows through the five goals of the PRN: (1) the easy button, (2) real-time data knowledge, (3) automated documentation, (4) touchless technology, and (5) flexible spaces (Holston, 2022). The easy button refers to access to patient data and information for the clinicians when they need it. Real-time data knowledge provides the best data and information possible at the time of care so that the clinicians can make informed diagnoses and decisions. Automated documentation allows the clinicians to spend less time in the EHR and more time with their patients. Touchless technology uses equipment such as cameras and sensors to monitor the patient without disturbance. Flexible spaces allow healthcare institutions to repurpose areas not currently used to provide patient care into patient care spaces; when these patient care areas are no longer needed, they can be returned to their former state. PRN is an

agile, integrated framework for healthcare environments that improves the quality of care and enhances the patient experience, no matter where health care is provided, by doing the following:

- Augmenting important real-time patient information into care processes
- Improving caregivers' efficiency by reducing or removing complicated interactions with technology
- Reducing patient-invasive touch without reducing care and personal interactions that increase satisfaction
- Engaging the patient and family in a way that reduces mental stress and improves satisfaction with care
- Allowing care to flex into alternate areas as needs arise and change (This Week Health, 2022, para. 2)

Therefore, PRN is making the processes, workflows, and technologies seamless.

Optimization

Most of what has been and will be discussed in this chapter is related to workflow analysis in conjunction with technology implementations. Nevertheless, not all workflow analysis and redesign occur before the implementation of technology. Some analysis and redesign efforts may occur weeks, months, or even years following the implementation. When workflow analysis occurs after implementation, it is often referred to as optimization. Optimization is the process of moving conditions past their current state and into more efficient and effective methods of performing tasks. Merriam-Webster (n.d.) defined optimization to be the act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible. Some organizations will routinely engage in optimization efforts following an implementation, whereas other organizations may

undertake this activity in response to clinicians' concerns or a marked change in operational performance.

Furthermore, workflow analysis can be conducted either as a stand-alone effort or as part of an operational improvement event. When the process is addressed alone, the effort is termed *process improvement*. Nursing informatics professionals should always be included in these activities to represent the needs of clinicians and to serve as a liaison for technological solutions to process problems. In addition, informaticists will likely become increasingly operationally focused and will need to transform their role accordingly to address workflow in an overall capacity as well as respective to technology. As mentioned earlier, hospitals tend to operate with smaller profit margins than other industries, and these profits will likely continue to diminish, forcing organizations to work smarter, not harder, and to use technology to accomplish this goal.

If optimization efforts are undertaken, the need to revisit workflow design should not be considered a flaw in the implementation approach. Even a well-designed future-state workflow during a technology implementation must be reexamined after implementation to ensure that what was projected about the future state remains valid and to incorporate any additional workflow elements into the process redesign.

Exploring the topic of workflow analysis regarding clinical technology implementation will yield considerably fewer literature results than searching for other topical areas of implementation. More research is needed in the area of the financial implications of workflow inefficiencies and their impact on patient care. Time studies require an investment of resources and may be subject to patient privacy issues as well as the challenges of capturing time measurements on processes that are not exactly replicable. Another confounding factor affecting the quality and quantity of workflow research is the lack of standardized terminology for this area. A comprehensive literature search was conducted and published through the AHRQ in 2008 as an evidence-based handbook for nurses; this literature search yielded findings indicating that a lack of standardized terminology in the area of workflow and publications

on this topic have made it a difficult subject to support through research findings. Stitt (2021) outlined some of the difficulties associated with different operations and different terminologies found in IT operations and security operations. He described the two teams as typically opposing rather than cooperating for the good of the organization and stressed the need for them to speak a common language. "While things like terminology, user interface preferences and workflows will need to be addressed, getting alignment about the sources of data is an important first step, allowing decisions to be made based on a common set of information" (p. 11).

What all organizations ultimately strive for is efficient and effective delivery of patient care. The terms *efficient* and *effective* are widely known in quality areas, or Six Sigma and Lean departments, but are not necessarily known or used in informatics. Effective delivery of care or workflow suggests that the process or end product is in the most desirable state. An efficient delivery of care or workflow would mean that little waste—that is, unnecessary motion, transportation, overprocessing, or defects—was incurred. Some health systems, such as Virginia Mason University Village Medical Center, have experienced significant quality and cost gains from the widespread implementation of Lean throughout their organizations.

Workflow Analysis and Informatics Practice

The American Nurses Association (ANA), in *Nursing Informatics: Scope and Standards of Practice* (2015, 2022), defined functional areas of practice for the informatics nurse specialist (INS). The functional area of analysis identified the specific functional qualities related to workflow analysis. Particularly, the ANA indicated that the INS should develop techniques necessary to assess and improve human–computer interaction. Workflow analysis is a central part of every INS function. The INS needs to understand workflow and appreciate how lack of efficient workflow negatively affects patient care.

A critical aspect of the informatics role is workflow design. Nursing informatics is uniquely positioned to engage in the analysis and redesign of processes and tasks surrounding the use of technology. The ANA (2015) cited workflow redesign as one of the fundamental skill sets that make up the discipline of this specialty. The ANA (2022) stated that the INS raises workflow and clinical practice awareness. Moreover, workflow analysis should be part of every technology implementation, and the role of the informaticist within this team is to direct others in the execution of this task or to perform the task directly.

Unfortunately, many nurses still find themselves in an informatics capacity without sufficient preparation for a **process analysis** role. One area of practice that is particularly susceptible to inadequate preparation is the ability to facilitate process analysis. Workflow analysis requires careful attention to detail and the ability to moderate group discussions, organize concepts, and generate solutions. These skills can be acquired through a formal academic informatics program or through courses that teach the concepts of Six Sigma or Lean by example. Regardless of where these skills are acquired, it is important to understand that they are now and will continue to be a vital aspect of the informatics role.

Some organizations have felt strongly enough about the need for workflow analysis that departments have been created to address this very need. Whether the department carries the name of clinical excellence, organizational effectiveness, or Lean Six Sigma, it is critical to recognize the value this group can offer technology implementations and clinicians.

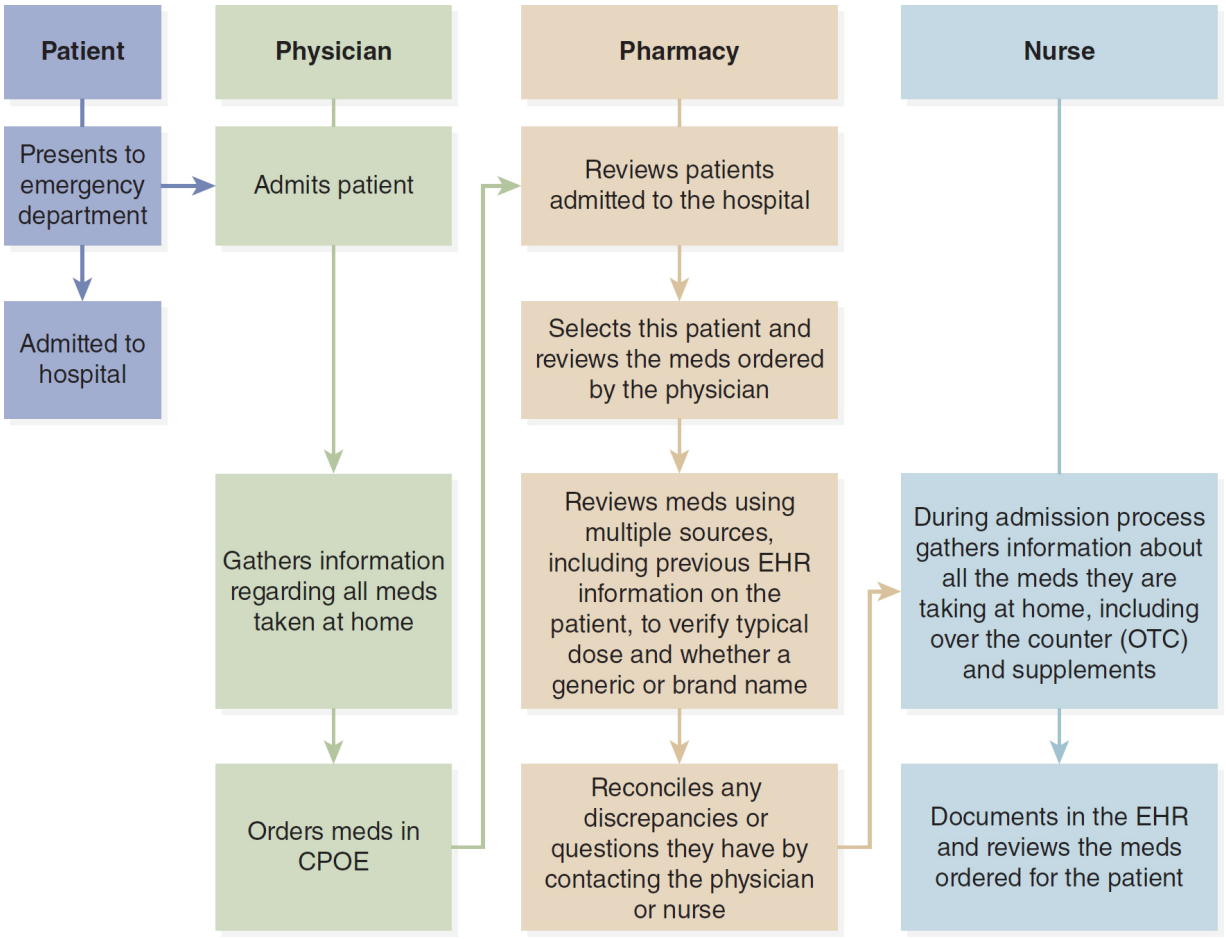
As we examine how workflow analysis is conducted, note that although the nursing informaticist is an essential member of the team that participates in or enables workflow analysis, a team dedicated to this effort is necessary for its success.

Building the Redesign Team

The workflow redesign team is an interdisciplinary team consisting of process owners. **Process owners** are those persons who directly engage in the workflow to be analyzed and redesigned. These individuals can speak about the intricacy of the process, including process variations from the norm. When constructing the team, it is important to include individuals who are able to contribute information about the exact current state of the workflow and offer suggestions for improvement of its future state. Members of the workflow redesign team should also have the authority to make decisions about how the process should be redesigned. Sometimes this authority is issued by managers, or it could come from participation of the managers directly. Such a careful blend of decision-makers and process owners can be difficult to assemble but is critical for forming the team and enabling it to succeed. Often, individuals at the managerial level will want to participate exclusively in the redesign process. Although having management participate provides the advantage of having decision-makers and management-level buy-in, these individuals may also make erroneous assumptions about how the process should be versus how the process is truly occurring. Conversely, including only process owners who do not possess the authority to make decisions can slow down the work of the team while decisions are made outside the group sessions.

Team focus needs to be addressed at the outset of the team's assembly. Early on, the team should decide which workflow will be examined to avoid confusion or spending time unnecessarily on workflow that does not ultimately matter to the outcome. In the early stages of workflow redesign, the team should define the beginning and end and a few high-level steps of the process. Avoid focusing on process steps in great detail in the beginning because the conversation can get sidetracked or team members may get bogged down by focusing on details and not moving along at a good pace. Six Sigma expert George Eckes uses the phrase "Stay as high as you can as long as you can," which is a great catchphrase to remember to keep the team focused and at a high level. The pace at which any implementation team progresses ultimately affects the overall timeline of a project; therefore, focus and speed are skills that the informatics expert should develop and use throughout every initiative but particularly when addressing workflow redesign.

The workflow redesign team will develop a detailed process map after agreement is reached on the current state of the beginning and end points of the process and after a high-level map depicting the major process steps is finalized. Because workflow crosses many care providers, it may be useful to construct the process map using a swim-lane technique (**Figure 13-2**). A swim-lane technique uses categories, such as functional workgroups, and roles to visually depict groups of work and who performs the work. The resulting map shows how workflow and data transition to clinicians and can demonstrate areas of potential process and information breakdowns.



Developed by Dee McGonigle.

Figure 13-2 Swim-Lane Workflow: Process for Medication Reconciliation When a Patient Is Admitted to the Hospital

Description

It may take several sessions of analysis to complete a process map as details are uncovered and workarounds discussed. There is a tendency for individuals who participate in process redesign sessions to describe workflow as they believe it to be occurring rather than how it really is. The informatics expert and/or the process team facilitator should determine what is really happening, however, and capture that information accurately. Regardless of whether a swim-lane or simplistic process map design is used, the goal is to capture

enough details to accurately portray the process as it is happening today.

Besides process mapping, other techniques may be used to help the team understand the workflow as it exists in its current state. Future-state workflow planning will only be as good as the reliability of the current state; thus, it is crucial to undertake whatever other actions are needed to better understand what is happening in the current state. Observation, interviews, and process or waste walks are also helpful in understanding the current state. Waste walks are a method of observing work as it is performed to note any waste or inefficient practices. It is important to make sure that all findings are shared with the nurses who were observed.

Value Added Versus Non–Value Added

Beyond analysis of tasks, current-state mapping provides the opportunity for the process redesign team to distinguish between value-added and non–value-added activities. A value-added step is one that ultimately brings the process closer to completion or changes the product or service for the better. An example of a value-added step would be placing a name tag on a specimen sample. The name tag is necessary for the laboratory personnel to identify the specimen, and therefore its placement is an essential, or value-added, step in the process. Some steps in a process do not necessarily add value but are needed for regulatory or compliance reasons; therefore, they must be included in the future process. In contrast, a non–value-added step does not alter the outcome of a process or product. Activities such as handling, moving, and holding are not considered value-added steps and should be evaluated during workflow analysis. Manipulating papers, moving through computer screens, and walking or transporting items are considered non–value-added activities.

The five whys represent one technique for driving the team toward identifying value-added versus non–value-added steps. The process redesign facilitator will query the group about why a specific

task is done or is done in a particular way through a series of questions asking why. The goal is to uncover tasks that came about due to workarounds or for other unsubstantiated reasons. Tasks that are considered non–value added and that are not necessary for the purpose of compliance or regulatory reasons should be eliminated from the future-state process. The team's purpose in redesigning workflow is to eliminate steps in a process that do not add value to the end state or that create waste by their very nature.

Waste

A key underpinning of the Lean philosophy is the removal of waste activities from workflow. Waste is classified as unnecessary activities or an excess of products used to perform tasks. The seven categories listed here are the most widely recognized forms of waste:

- Overproduction: pace is faster than necessary to support the process
- Waiting
- Transport
- Inappropriate processing: overprocessing
- Unnecessary inventory: excess stock
- Unnecessary motion: bending, lifting, moving, and so on
- Defects: reproduction

Variation

The nature of the work situation for the nurse is one of frequent interruptions, which cause the workflow to be disrupted and increase the chance of error (Wang & Jin, 2021; Yuan et al., 2013). Variation in workflow is considered the enemy of all good processes and therefore should be eliminated when possible. Variation occurs when workers perform the same function in different ways. This situation

usually arises because of flaws in the way a process was originally designed, lack of knowledge about the process, or inability to execute a process as originally designed due to disruption or disturbances in the workflow. Examining the process as it exists today will help with identifying variation. Some variation cannot be eliminated because processes that involve highly customized products or services are generally not conducive to standardization and the elimination of variation inherent to the process.

Some people argue that delivery of care is subject to variation owing to its very nature and to the individual needs of patients. There is little doubt that each patient's care should be tailored to meet their specific needs. Nevertheless, delivery of care involves some common processes that can be standardized and improved upon without jeopardizing care.

Transitioning to the Future State

Following redesign efforts, regardless of whether they occurred during or after an implementation or as a stand-alone process improvement event, steps must be taken to ensure that change takes hold and that the new workflow continues after the support team has disbanded. Management support and involvement during the transition phase is essential because management will be necessary to enforce new workflow procedures and further define and refine roles and responsibilities. Documentation of the future-state workflow should have occurred during the redesign effort but is not completely finished until after the redesign is complete and the workflow has become operational. Policies and procedures are addressed and rewritten to encompass the changes to workflows and role assignments. Help desk, system analyst, nursing education, and other support personnel need to be educated about the workflow specifics as part of the post-improvement effort. It is considered good practice to involve the operational staff in the future process discussions and planning in order to incorporate specifics of these areas and to ensure staff buy-in.

Workflow changes beginning to fail and workarounds developing signal that something is flawed about the way in which the new process was constructed and that it needs to be evaluated further. The workflow redesign team is then brought together to review and, if necessary, redesign the process.

The future state is constructed with the best possible knowledge of how the process will ideally work. To move from the current state to the future state, gap analysis is necessary. Gap analysis zeroes in on the major areas most affected by the change—namely, technology. What often happens in redesign efforts is an exact or near-exact replication of the current state using automation. The gap analysis discussion should generate ideas from the group about how best to utilize the technology to transform practice. A prudent step is to consider having legal and risk representatives at the table when initiating future-state discussions to identify the parameters within which the group should work; nevertheless, the group should not assume that the existing parameters are its only boundaries.

Future-state process maps become the basis of educational materials for end users, communication tools for the project team, and the foundation of new policies and procedures. Simplified process maps provide an excellent schematic for communicating change to others.

Informatics as a Change Agent

Technology implementations represent a significant change for clinicians, as does the workflow redesign that accompanies adoption of technology. Often, the degree of change and its impact are underappreciated and unaccounted for by leadership and staff alike. A typical response to change is anger, frustration, and a refusal to accept the proposed change. All these responses should be expected and need to be accounted for; thus, a plan to address the emotional side of change is developed early on. Every workflow redesign effort should begin with a change management plan (**Figure 13-3**). Engagement of the end user is a critical aspect of change management and therefore technology adoption. Without end user involvement, change is resisted and efforts are subject to failure. Users may be engaged and brought into the prospective change through question-and-answer forums, technology demonstrations, and frequent communications regarding change and as department-specific representatives in working meetings.



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Figure 13-3 Change Management

Many change theories have been developed. No matter which change theory is adopted by the informatics specialist, however, communication, planning, and support are key factors in any change management strategy. Informaticists should become knowledgeable about at least one change theory and use this knowledge as the basis for change management planning as part of every effort. John Kotter (1996), one of the most widely recognized change theorists, suggested that the following conditions must be addressed to deal with change in an organization:

- Education and communication
- Participation and involvement
- Facilitation and support
- Negotiation and agreement

- Manipulation and cooptation
- Explicit and implicit coercion

In the Healthcare Information and Management Systems Society (HIMSS) (2022) Nursing Informatics Workforce Survey, the crucial role that nurse informaticists play in enhancing healthcare, driving innovation and technology to achieve the full health promise of every human, was validated. Nurse informaticists "use project and change management expertise and optimize electronic medical health records, quality initiatives and reporting" (HIMSS, 2022, para. 1). Nursing informaticists are the most significant resource in a project team that influences adoption and change management since they bring to such teams their ability to interact with various clinicians, knowledge of clinical practice, and the ability to empathize with the clinicians as they experience the impact of workflow change. These innate skills differentiate the nursing informaticist from other members of the implementation team and are highly desirable in the informatics community.

Nevertheless, no matter which change management techniques are employed by the informatics specialist and the project team, the adoption of technology and workflow may be slow to evolve. Change is often a slow process that requires continual positive reinforcement and involvement of supporting resources. Failure to achieve strong adoption results early on is not necessarily a failure of the methods utilized but rather may be due to other factors not entirely within the control of the informaticist.

Perhaps a complete alteration in behavior is not possible, but modifications to behaviors needed to support a desired outcome can be realized. This situation is analogous to the individual who stops smoking; the desire for the cigarette remains, but the behavior has been modified to no longer sustain smoking. To manage change in an organization, nurses must modify behavior to produce the intended outcome.

Change takes hold when strong leadership support exists. This support manifests itself as a visible presence to staff, clear and

concise communications, an unwavering position, and an open-door policy to field concerns about change. Too often, leadership verbally endorses change and then fails to follow through with these actions or withdraws support when the going gets tough. Inevitably, if leadership wavers, so, too, will staff.

Measuring the Results

Metrics provide an understanding about the performance of a process or function. Typically, within clinical technology projects, metrics about the performance of the technology or that capture the level of participation or adoption are identified and collected. Equally important is the need for process performance metrics. Process metrics are collected at the initial stage of project or problem identification. Current-state metrics are then benchmarked against internal indicators. When there are no internal indicators to benchmark against, a suitable course of action is to benchmark against an external source, such as a similar business practice within a different industry. Consider examining the hotel room changeover strategy or the customer service approach of Disney or Ritz-Carlton hotels, for example, to determine suitable metrics for a particular project or focus area.

The right workflow complement will provide the organization with the data it needs to understand operational and clinical performance. This area is highlighted through the need for healthcare organizations to capture MACRA measures. Good metrics should tell the story of accomplishment. The presence of technology alone does not guarantee an organization's ability to capture and report on these measures without also addressing the surrounding workflow. Metrics should focus on the variables of time, quality, and costs. **Table 13-1** provides examples of relevant metrics.

TABLE 13-1 Examples of Metrics

Turnaround times	Cycle times	Throughput
Changeover time	Setup time	System availability
Patient satisfaction	Employee satisfaction	

MACRA highlights the need for healthcare organizations to collect information that represents the impact of technology on patient outcomes. Furthermore, data are necessary to demonstrate how a process is performing in its current state. In spite of the MACRA mandates, the need to collect data to demonstrate improvement in workflow—though it remains strong—is all too often absent in implementation or redesign efforts. A team cannot demonstrate improvements to an existing process without collecting information about how the process is performing today. Current-state measures also help the process team validate that the correct area for improvement was identified. Once a process improvement effort is over and the new solution has been implemented, post-improvement measures should be gathered to demonstrate progress.

In some organizations, the informatics professional reports to the director of operations, the chief information officer, or the chief operations officer. In this relationship, the need to demonstrate operational measures is even stronger. Some of the operational measures captured are turnaround times, throughput, and equipment or technology availability.

Quality Improvement Initiatives

Thus far, we have focused on workflow considerations in relation to the adoption, implementation, and optimization of new technology. We turn now to another critical role for the nurse informaticist, **quality improvement (QI)**. QI consists of a systematic process using data and continuous actions that leads to measurable improvement in healthcare services and the health status of targeted patient groups. QI projects use many of the same techniques that we discussed for workflow—namely, process mapping, team buy-in, and attention to change theories. They are also dependent on metrics to accurately assess the nature of the issue to be addressed and to measure the success of the project. Health Catalyst (2022) suggested the following broad categories for potential hospital QI projects: "clinical variation, preventable medical errors, hospital acquired infections, delays in patient discharge, and dwindling cash flow" (para. 1). As with any project, it is critical to choose wisely; select the topic to address, a great team, a process that is likely to succeed, and the most reliable metrics. In addition to relational skills, such as collaboration and communication, Jones et al. (2019) identified these key characteristics that QI change agents need: "[e]nthusiasm, optimism, curiosity, and perseverance" (para. 5).

Systematic change requires attention to the processes and metrics necessary to successfully enact the change. QI is dependent on four key principles for success: the need to understand current systems and processes, to focus on patient needs and expectations, to focus on teamwork, and to be data driven. The Somerset NHS Foundation Trust (n.d.) outlined the following seven key steps in a QI project:

1. Select the QI team members based on their knowledge of the issue to be solved and their ability to contribute meaningfully to the team.
2. Select the project by considering performance gaps, the problem, the relationship to the organization's strategic plan,

staff input and/or resistance, and feasibility and timing.

3. Develop the aim statement using a SMART (specific, measurable, achievable, relevant, and time-bound) approach. The aim statement should be specific enough so that the what, why, who, when, and how of the project are readily apparent.
4. Develop measures to determine whether project goals were met while keeping in mind that a change in one area may create issues for another area. A QI project must consider these critical organizational balancing issues.
5. Identify change ideas.
6. Test changes.
7. Develop a process for sustainability and spread.

You should always celebrate success. This is a necessary component and time well spent, but it does not always occur. Reflecting on and appreciating the work that went into the project and celebrating its success are critical to recognizing this effort and the desired outcomes.

Future Directions

Workflow analysis is not an optional part of clinical implementations but rather is a necessity for safe patient care supported by technology. The ultimate goal of workflow analysis is to create a future-state solution that maximizes the use of technology and eliminates non–value-added activities. Although many tools are available to accomplish workflow redesign, the best method is the one that complements the organization and supports the work of clinicians. Redesigning how people do work will provide evidence to create change; thus, the nursing informaticist will need to apply change management principles for the new way of doing things to take hold. These statements are also true of QI projects.

Workflow analysis and QI have been described in this chapter within the context of the most widely accepted tools that are fundamentally linked to the concepts of Lean Six Sigma. Other methods of workflow analysis and QI exist and may also be used to assess clinical workflow. An example of an alternative workflow analysis tool is the use of radio-frequency badges to detect movement within a defined clinical area. Clinician and patient movements may be tracked using these devices, and corresponding actions may be documented, which together paint a picture of the workflow for a specific area (Vankipuram et al., 2011).

Another example of a workflow analysis tool involves the use of modeling software. An application such as ProModel provides images of the clinical work area where clinician workflows can be plotted out and reconfigured to best suit the needs of a specific area. Simulation applications enable decision-makers to visualize realistic scenarios and draw conclusions about how to leverage resources, implement technology, and improve performance. Other vendors that offer simulation applications include Maya and Autodesk.

Healthcare organizations need to consider how other industries have analyzed and addressed workflow to streamline business practices and improve quality outputs to glean best practices that

might be incorporated into the healthcare industry's own clinical and business approaches. First, however, each healthcare organization must step outside itself and recognize that not all aspects of patient care are unique; consequently, many aspects of care can be subjected to standardization. Many models of workflow redesign from manufacturing and the service sector can be extrapolated to health care. The healthcare industry is facing difficult economic times and can benefit from performance improvement strategies used in other industries.

Although workflow analysis principles have been described in this chapter within the context of acute and ambulatory care, the need to perform process analysis on a macro level will expand as more organizations move forward with **health information exchanges (HIEs)** and **medical home models**. An HIE requires the nursing informaticist to visualize how patients move through the entire continuum of care and not just a specific patient care area.

Technology initiatives will become increasingly complex in the future. In turn, nursing informaticists will need greater preparation in the area of process analysis and improvement techniques to meet the growing challenges that technology brings and the operational performance demands of fiscally impaired healthcare organizations.

Summary

Workflows integrating technology provide the healthcare professional with the data necessary to make informed decisions. This quality data must be collected and captured to meet MACRA measures. Nurses are the healthcare team members who spend the most time with patients. Therefore, the nurses must be involved in "meaningful data collection and reporting. Documentation by nurses can tell what's going on with the patient beyond physical exams, test results, and procedures" (Daley, 2011, para. 5).

Workflow redesign is a critical aspect of technology implementation. When done well, it yields technology that is more likely to achieve the intended patient outcomes and safety benefits. Nursing informatics professionals are taking on a greater role regarding workflow design, and this aspect of practice will grow in light of MACRA-driven measures. QI initiatives that affect hospital performance will also drive informatics professionals to influence how technology is used in the context of workflow and QI to improve the bottom line for their organizations. In an ideal world, nurse informaticists who are experts at workflow analysis and QI would be core members of every organization.

THOUGHT-PROVOKING QUESTIONS

1. What do you perceive as the current obstacles to redesigning workflow within your clinical setting?
2. Thinking about your last implementation, were you able to challenge the policies and practices that constitute today's workflow, or were you able to create a workflow solution that eliminated non–value-added steps?
3. Is the workflow surrounding technology usage providing the healthcare organization with the data it needs to make decisions and eventually meet MACRA criteria?
4. Describe your understanding of the PRN in detail. How is the PRN disrupting healthcare delivery?

5. How does the current educational preparation need to change to address the skills necessary to perform workflow analysis and QI?
6. Identify a process that would benefit from a QI project. Whom would you place on the team, and what steps would you initiate?

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SECTION IV
Nursing Informatics Practice Applications: Care Delivery

Chapter 14 The Electronic Health Record and Clinical Informatics

Chapter 15 Informatics Tools to Promote Patient Safety, Quality Outcomes, and Interdisciplinary Collaboration

Chapter 16 Patient Engagement and Connected Health

Chapter 17 Using Informatics to Promote Community and Population Health

Chapter 18 Telenursing and Remote Access Telehealth

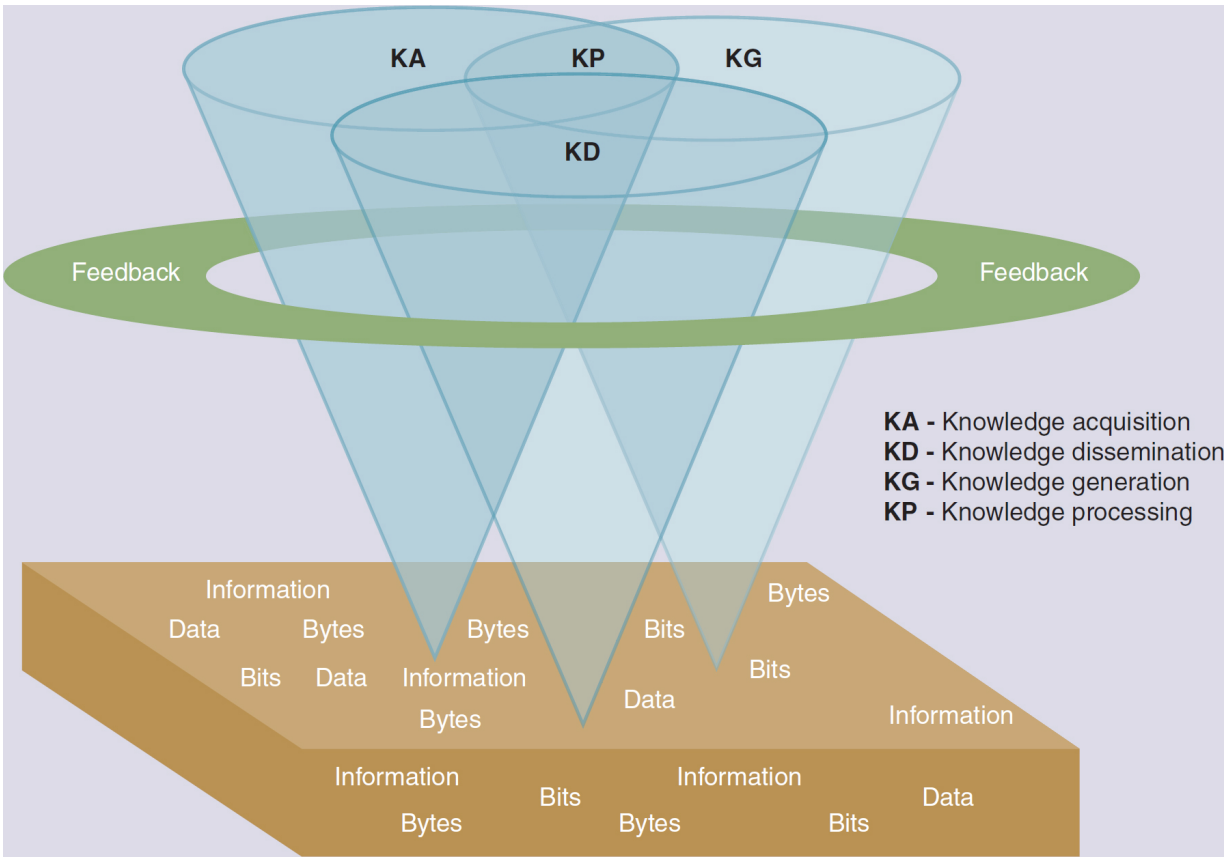
Nursing information systems must support nurses as they fulfill their roles in delivering quality patient care. Such systems must be responsive to nurses' needs, allowing them to manage their data and information as necessary and providing access to essential references, literature sources, and other networked departments. Nurses have always practiced in a field where they have needed to use their ingenuity, resourcefulness, creativity, initiative, and skills. To improve patient care and advance the science of nursing, clinicians as knowledge workers must apply these same abilities and skills to become astute users of available information systems.

In this section, the reader learns about clinical practice tools, electronic health records, and clinical information systems; informatics tools to enhance patient safety, provide consumer information, and meet education needs; population and community health tools; and telehealth and telenursing.

Information systems, electronic documentation, and electronic health records are changing the way nurses and physicians practice. Nursing informatics systems are also changing how patients enter

and receive data and information. Some institutions, for example, are permitting patients to access their own records electronically via the internet or a dedicated patient portal. Confidentiality and privacy issues loom with these new electronic systems. Health Insurance Portability and Accountability Act (HIPAA) regulations (covered in Section II, *Perspectives on Nursing Informatics*) and professional ethics principles (covered in Section I, *Building Blocks of Nursing Informatics*) must remain at the forefront when clinicians interact electronically with intimate patient data and information.

The material in this book is placed within the context of the Foundation of Knowledge model (**Figure IV-1**) to meet the needs of healthcare delivery systems, organizations, patients, and nurses. Readers should continue to assess their personal knowledge progression. The Foundation of Knowledge model challenges us to reflect on how our knowledge foundation is ever changing and to appreciate that acquiring new information is a key resource for knowledge building. This section addresses the information systems with which clinicians interact in their healthcare environments as affected by legislation; professional codes of ethics; consumerism; and reconceptualization of practice paradigms, such as in telenursing. All the various nursing roles—practice, administration, education, research, and informatics—involve the science of nursing.



Designed by Alicia Mastrian.

Figure IV-1 Foundation of Knowledge Model

Description



CHAPTER 14

The Electronic Health Record and Clinical Informatics

OBJECTIVES

1. Describe the common components of an electronic health record.
2. Assess the benefits of implementing an electronic health record.
3. Explore the ownership of an electronic health record.
4. Evaluate the flexibility of the electronic health record in meeting the needs of clinicians and patients.
5. Examine the impact on patient outcomes when social determinants of health are included in the electronic health record.

KEY TERMS

- administrative process
- American Recovery and Reinvestment Act (ARRA)
- connectivity
- decision support
- electronic communication
- electronic health record (EHR)
- health information
- Health Information Technology for Economic and Clinical Health (HITECH) Act
- interoperability

- meaningful use
- order entry management
- patient support
- population health management
- reporting
- results management
- social determinants of health (SDOH)

Introduction

The significance of **electronic health records (EHRs)** to nursing cannot be overestimated. Although EHRs on the surface suggest a simple automation of clinical documentation, in fact their implications are broad, ranging from the ways in which care is delivered, to the types of interactions nurses have with patients in conjunction with the use of technology, to the research surrounding EHRs that will inform nursing practice for tomorrow. Although EHR standards are evolving and barriers to adoption remain, the collective work has a positive momentum that will benefit clinicians and patients alike.

A basic knowledge of EHRs and nursing informatics is now considered by many to be an entry-level nursing competency. Various nursing work groups have delineated nursing informatics competencies from entry level to nursing informatics specialists, and other groups have identified competencies specific to the EHR. The American Health Information Management Association (AHIMA) collaborated with the Health Professions Network and the Employment and Training Administration to create a graphic depiction of competencies necessary for EHR interaction. The Health Information Management Competency model is divided into six levels: personal effectiveness competencies, academic competencies, workplace competencies, industry-wide technical competencies, industry-sector technical competencies, and a management competencies level shared with occupation-specific requirements. The Health Information Management Competency model can be viewed at www.careeronestop.org/competencymodel/competency-models/electronic-health-records.aspx. Hovering over each block in the model provides a definition of each of the competencies covered by the model. For example, the industry-sector technical competencies section includes health information literacy and skills, health informatics skills using the EHR, privacy and confidentiality of health information, and health information/data technical security.

The drive to adopt EHRs was underscored with the passage of the **Health Information Technology for Economic and Clinical Health (HITECH) Act** of 2009. It is essential that EHR competency be developed if nurses are to participate fully in the changing world of healthcare information technology.

This chapter has four goals. First, it describes the common components of an EHR. Second, it reviews the benefits of using an EHR. Third, it provides an overview of successful ownership of an EHR, including nursing's role in promoting the safe adoption of EHRs in day-to-day practice. Fourth, it discusses the flexibility of an EHR in meeting the needs of both clinicians and patients and emphasizes the need for fully interoperable EHRs and clinical information systems (CISs).

Setting the Stage

The U.S. healthcare system faces the enormous challenge of improving quality of care while simultaneously controlling costs. EHRs were proposed as one solution to achieve this goal (Institute of Medicine [IOM], 2001). In January 2004, President George W. Bush raised the profile of EHRs in his State of the Union Address by outlining a plan to ensure that most Americans have an EHR by 2014. He stated that "by computerizing health records, we can avoid dangerous medical mistakes, reduce costs and improve care" (Bush, 2004). This proclamation generated an increased demand for understanding EHRs and promoting their adoption, but relatively few healthcare organizations were motivated at that time to pursue adoption of EHRs. Congress passed the **American Recovery and Reinvestment Act (ARRA)** of 2009. This legislation included the HITECH Act, which specifically sought to incentivize health organizations and providers to become meaningful users of EHRs. These incentives came in the form of increased reimbursement rates from the Centers for Medicare and Medicaid Services (CMS); ultimately, the HITECH Act resulted in payment of a penalty by any healthcare organization that had not adopted an EHR by January 2015. The Healthcare Information and Management Systems Society (HIMSS) has been tracking EHR adoption since 2005 through its Stage 7 validation and in 2013 reported that most U.S. healthcare organizations (77%) were in Stage 3, reflecting implementation of only the basic EHR components of laboratory, radiology, and pharmacy ancillaries; a clinical data repository, including a controlled medical vocabulary; and simple nursing documentation and clinical decision support (HIMSS, n.d.-a, 2014, 2017). Higher stages of the EHR adoption model include more sophisticated use of clinical decision support systems and medication administration tools, with HIMSS Stage 7—the highest level—consisting of EHRs that have data sharing and warehousing capabilities and are completely interfaced with emergency and outpatient facilities (Burkey, 2015; HIMSS, n.d.-

c, 2017). Real progress is being made on the adoption of more robust EHRs. HIMSS (n.d.-c) reports that 1,313 hospitals in the United States have achieved Stage 6, with full physician documentation, a robust clinical decision support system, and electronic access to medical images. Burkey (2015) reported that, to date, over 200 hospitals have achieved Stage 7 and are totally paperless and that more organizations reach this goal every day. Overall, 96% of U.S. hospitals and 78% of physicians' offices have adopted an EHR (Office of the National Coordinator for Health Information Technology, n.d.).

Components of Electronic Health Records

Overview

Before enactment of the ARRA, several variants of EHRs existed, each with its own terminology and each developed with a different audience in mind. The sources of these records included, for example, the federal government (HIMSS, n.d.-a, 2017; IOM, 2003) and the National Institutes of Health (2006). The ARRA included an explicit requirement for providers and hospitals to use a certified EHR that meets a set of standard functional definitions to be eligible for an increased reimbursement incentive. Standards, standardized functions, and standard terminology requirements are important considerations so that information can be easily shared among providers. Initially, the U.S. Department of Health and Human Services (HHS) granted two organizations the authority to accredit EHRs: the Drummond Group and the Certification Commission for Healthcare Information Technology. These bodies are authorized to test and certify EHR vendors against the standards and test procedures developed by the National Institute of Standards and Technology (NIST) and endorsed by the Office of the National Coordinator for Health Information Technology (ONC) for EHRs. The number of certification bodies recognized by the ONC changes over time; for current information, see www.healthit.gov/topic/certification-ehrs/about-onc-health-it-certification-program.

The initial NIST test procedure included 45 certification criteria, ranging from the basic ability to record patient demographics, document vital signs, and maintain an up-to-date problem list to more complex functions, such as electronic exchange of clinical information and patient summary records (NIST, 2010a). **Box 14-1** lists the 45 certification criteria outlined by NIST in 2010. These criteria have been updated several times since 2010, with the 2015 version developed after going out for public comment (ONC, 2023).

In 2020, the changes that are now reflected in the revised criteria resulted from the implementation of the 21st Century Cures Act (Federal Register, 2020a, 2020b). Each iteration of certification criteria and testing procedures seeks to make the EHR more robust, interoperable, and functional to meet the needs of patients and users.

BOX 14-1 EHR CERTIFICATION CRITERIA

Criteria #	Certification Criteria
§170.302 (a)	Drug–drug, drug–allergy interaction checks
§170.302 (b)	Drug formulary checks
§170.302 (c)	Maintain up-to-date problem list
§170.302 (d)	Maintain active medication list
§170.302 (e)	Maintain active medication allergy list
§170.302 (f)(1)	Vital signs
§170.302 (f)(2)	Calculate body mass index
§170.302 (f)(3)	Plot and display growth charts
§170.302 (g)	Smoking status
§170.302 (h)	Incorporate laboratory test results
§170.302 (i)	Generate patient lists
§170.302 (j)	Medication reconciliation
§170.302 (k)	Submission to immunization registries
§170.302 (l)	Public health surveillance

Criteria #	Certification Criteria
§170.302 (m)	Patient-specific education resources
§170.302 (n)	Automated measure calculation
§170.302 (o)	Access control
§170.302 (p)	Emergency access
§170.302 (q)	Automatic log-off
§170.302 (r)	Audit log
§170.302 (s)	Integrity
§170.302 (t)	Authentication
§170.302 (u)	General encryption
§170.302 (v)	Encryption when exchanging electronic health information
§170.302 (w)	Accounting of disclosures (optional)
§170.304 (a)	Computerized provider order entry
§170.304 (b)	Electronic prescribing
§170.304 (c)	Record demographics
§170.304 (d)	Patient reminders
§170.304 (e)	Clinical decision support
§170.304 (f)	Electronic copy of health information
§170.304 (g)	Timely access
§170.304 (h)	Clinical summaries

Criteria #	Certification Criteria
§170.304 (i)	Exchange clinical information and patient summary record
§170.304 (j)	Calculate and submit clinical quality measures
§170.306 (a)	Computerized provider order entry
§170.306 (b)	Record demographics
§170.306 (c)	Clinical decision support
§170.306 (d) (1)	Electronic copy of health information
§170.306 (d) (2)	Electronic copy of health information Note: For discharge summary
§170.306 (e)	Electronic copy of discharge instructions
§170.306 (f)	Exchange clinical information and patient summary record
§170.306 (g)	Reportable lab results
§170.306 (h)	Advance directives
§170.306 (i)	Calculate and submit clinical quality measures

It is important to see the criteria first established by the ONC in 2010. In 2015, the new requirements expanded from 45 to 60 criteria organized into eight certification criteria categories (ONC, 2015). The categories follow:

1. Clinical Processes
2. Care Coordination
3. Clinical Quality Measurement
4. Privacy and Security
5. Patient Engagement
6. Public Health

7. Health IT Design and Performance
8. Electronic Exchange

According to the Federal Register (2020a), the 21st Century Cures Act changed the 2015 criteria. This final rule by the ONC updated the 2015 criteria by removing several certification criteria. This final rule implements certain provisions of the 21st Century Cures Act, including the following:

> *Conditions and Maintenance of Certification requirements for [health IT] developers under the ONC Health IT Certification Program, the voluntary certification of health IT for use by pediatric health care providers, and reasonable and necessary activities that do not constitute information blocking.* (Federal Register, 2020b, para. 1)

It also updated some of the "certification criteria to reflect standard and implementation specification updates. In consideration of public comments, the final rule adds only two new technical certification criteria and two new attestation-structured privacy and security certification criteria" (Federal Register, 2020a, para. 8).

Reproduced from: National Institute of Standards and Technology. (2010b). *Meaningful use test method: Approved test procedures version 1.0.* www.nist.gov/news-events/news/2010/08/nist-publishes-approved-testing-procedures-electronic-health-records

Despite the points articulated in the ARRA, the IOM definition of an EHR also remains a valid reference point. This definition is useful because it has distilled all the possible features of an EHR into eight essential components with an emphasis on functions that promote patient safety—a universal denominator that everyone in health care can accept. The eight components are (1) health information and data, (2) results management, (3) order entry management, (4) decision support, (5) electronic communication and connectivity, (6) patient support, (7) administrative processes, and (8) reporting and population health management (IOM, 2003). These initial core components, as well as more recent modifications, described by the Health Resources and Services Administration (Green, 2023) and the components of a comprehensive EHR identified by the ONC (Charles et al., 2015) are described in more detail here. With the exception of EHR infrastructure functions, such as security and privacy management, controlled medical vocabularies, and **interoperability**

standards, the 45 initial NIST standards easily map onto the IOM categories.

Health Information and Data

Health information and data comprise the patient data required to make sound clinical decisions, including demographics, medical and nursing diagnoses, medication lists, allergies, and test results (IOM, 2003). This component of the EHR also includes care management data regarding details of patient visits and interactions with patients, medication reconciliation, consents, and directives (Green, 2023). A comprehensive EHR will also contain nursing assessments and problem lists (Charles et al., 2015). According to the ONC (2019a), the EHR is a digital, or electronic, record that can provide comprehensive health information about patients. The EHR systems are designed to disseminate patient information to healthcare providers, laboratories, imaging centers, pharmacies, clinics, and other organizations involved in the patient's care.

Results Management

Results management is the ability to manage results of all types electronically, including both current and historical laboratory and radiology procedure reports (IOM, 2003).

Order Entry Management

Order entry management is the ability of a clinician to enter medication and other care orders, including laboratory, microbiology, pathology, radiology, nursing, and supply orders; ancillary services; and consultations, directly into a computer (IOM, 2003). A comprehensive EHR will also contain nursing orders (Charles et al., 2015).

Decision Support

Decision support entails the use of computer reminders and alerts to improve the diagnosis and care of a patient, including screening for correct drug selection and dosing; screening for medication interactions with other medications; preventive health reminders in such areas as vaccinations, health risk screening, and detection; and clinical guidelines for patient disease treatment (IOM, 2003). The National Academy of Medicine (2017) reflected that the core potential of health information technology is its promise to revolutionize the data, information, knowledge, and wisdom (DIKW) process and alleviate the challenges related to clinical decision support. It believed that health information technology must be able to "ameliorate the burden that exponentially expanding clinical knowledge as well as care and choice complexity place on the finite time and attention of clinicians, patients, and every other member of the care team" (p. 1). Incorporating decision support into the EHR is crucial for the delivery of the right data, information, and knowledge to healthcare providers to offer the best support for advocated or recommended clinical decisions. Therefore, the EHR must consistently provide the best available data, information, and knowledge in the context of the patient's needs that can be applied to the patient's healthcare goals. Healthcare providers must be able to access the right data and information at the right time and in the proper format to facilitate their decision and care processes to optimize patient care and outcomes.

Electronic Communication and Connectivity

Electronic communication and **connectivity** include the online communication among healthcare team members and their care partners and with their patients, which includes email; web messaging; and an integrated health record within and across settings, institutions, and telemedicine (IOM, 2003). This component has been expanded to include the interfaces and interoperability

required to exchange health information with other providers, laboratories, pharmacies (i.e., e-prescribing), patients, and government disease registries (Green, 2023). The ONC (2019a) believes that the EHR interfacing has the potential to reduce the fragmentation of care by enhancing care coordination.

Patient Support

Patient support encompasses patient education and self-monitoring tools, including interactive computer-based patient education, home telemonitoring, and telehealth systems (IOM, 2003).

Administrative Processes

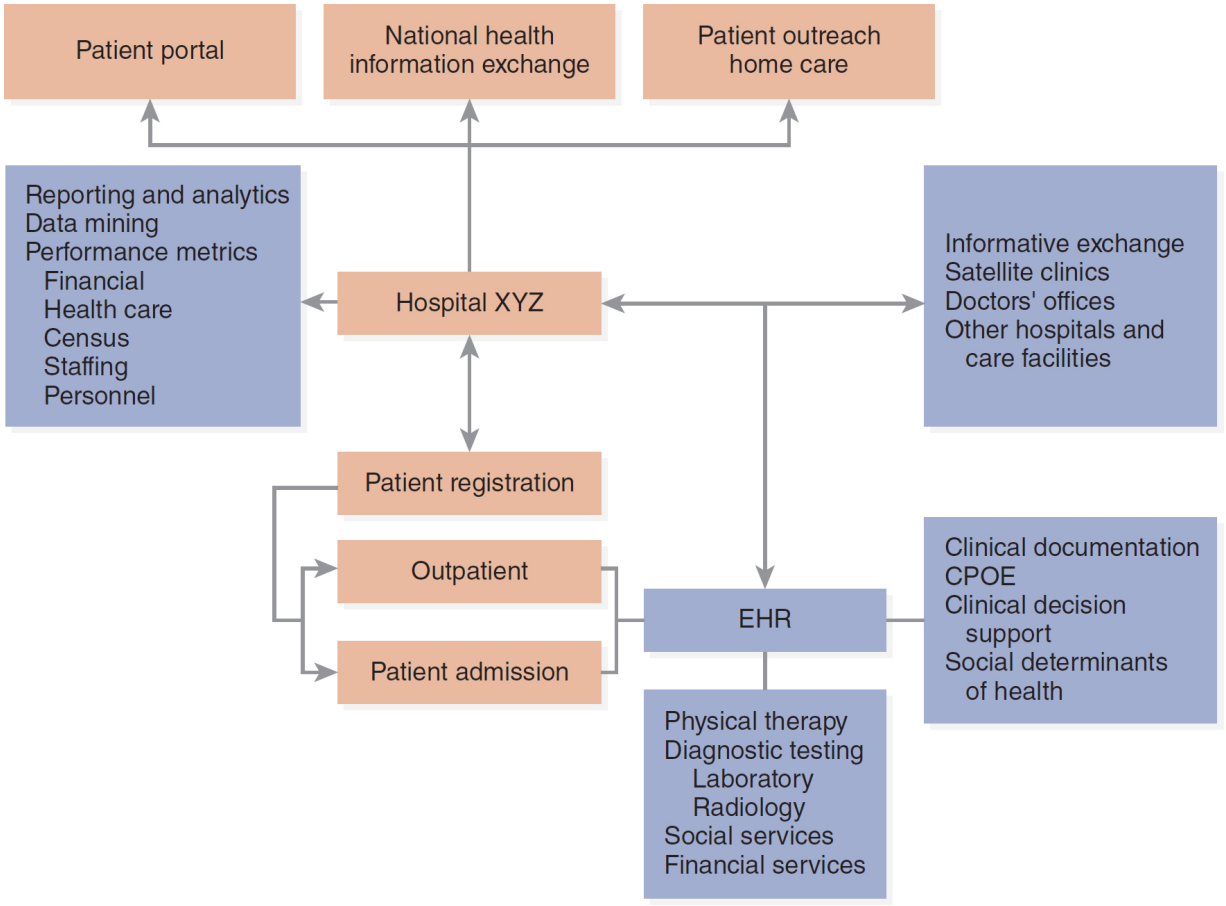
Administrative processes are activities carried out by the electronic scheduling, billing, and claims management systems, including electronic scheduling for inpatient and outpatient visits and procedures, electronic insurance eligibility validation, claim authorization and prior approval, identification of possible research study participants, and drug recall support (IOM, 2003).

Reporting and Population Health Management

Reporting and **population health management** are the data collection tools that support public and private reporting requirements, including data represented in a standardized terminology and machine-readable format (IOM, 2003).

NIST has not provided an exhaustive list of all possible features and functions of an EHR. Consequently, vendors' EHR systems combine different components in their offerings, and often a single set of EHR components may not meet the needs of all clinicians and patient populations. For example, a pediatric setting may demand functions for immunization management, growth tracking, and more robust order entry features that include weight-based dosing

(Spooner & Council on Clinical Information Technology, 2007). These types of features may not be provided by all EHR systems, and it is important to consider EHR certification to be a minimum standard. See **Figure 14-1** for a graphic depiction of leveraging the EHR.



Courtesy of Dr. Dee McGonigle.

Figure 14-1 Leveraging the EHR

Description

Another group that focuses on EHR standards and functionality is Health Level Seven International (HL7). Founded in 1987, "Health Level Seven International (HL7) is a not-for-profit, ANSI-accredited standards developing organization dedicated to providing a comprehensive framework and related standards for the exchange,

integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services" (HL7 International, n.d., para. 1). This group concentrates on developing the behind-the-scenes programming standards (Level Seven is the application level of the Open Systems Interconnection model) for interfaces to ensure interoperability and connectivity among systems.

Advantages of Electronic Health Records

Measuring the benefits of EHRs can be challenging. Possible methods for estimating EHR benefits include using data supplied by vendors that have been retrieved from their customers' systems, synthesizing and applying studies of overall EHR value, creating logical engineering models of EHR value, summarizing focused studies of elements of EHR value, and conducting and applying information from site visits (ONC, 2017a; Thompson et al., 2007).

Early in their development, the four most-cited benefits of EHRs were (1) increased delivery of guidelines-based care, (2) enhanced capacity to perform surveillance and monitoring for disease conditions, (3) reduction in medication errors, and (4) decreased use of care (Chaudhry et al., 2006; ONC, 2017a). These findings were echoed by two similar literature reviews. The first review, by Dorr et al. (2007), focused on the use of informatics systems for managing patients with chronic illness. They found that the processes of care that were most positively affected were guidelines adherence, visit frequency (i.e., a decrease in emergency department visits), provider documentation, patient treatment adherence, and screening and testing.

The second review, by Shekelle et al. (2006), was a cost-benefit analysis of health information technology, completed by the Agency for Healthcare Research and Quality, that studied the value of an EHR in ambulatory care and pediatric settings, including its overall economic value. Shekelle et al.'s study highlighted the common findings already described but also noted that most of the data available for review came from six leading healthcare organizations in the United States, which underscored the challenge of generalizing these results to the broader healthcare industry. The challenge to generalize results persists in the hospital arena, with fewer than 1% of U.S. hospitals, or eight leading organizations, providing most of the experience with comprehensive EHRs (HIMSS, n.d.-a, n.d.-c, 2017). Finally, the literature reviews cited here

indicated that there are a limited number of hypothesis-testing studies of EHRs and even fewer that have reported cost data.

The descriptive studies do have value, however, and should not be hastily dismissed. Although not as rigorous in their design compared to experimental studies, they do describe the advantages of EHRs well and often include useful implementation recommendations learned from practical experience. As identified in these types of reviews, EHR advantages include simple benefits, such as no longer having to interpret poor handwriting and handwritten orders; reduced turnaround time for laboratory results in an emergency department; and decreased time to administration of the first dose of antibiotics in an inpatient nursing unit (Husk & Waxman, 2004; ONC, 2017a). In the ambulatory care setting, improved management of cardiac-related risk factors in patients with diabetes and effective patient notification of medication recalls have been demonstrated to be benefits of the EHR (Jain et al., 2005; Reed & Bernard, 2005). Two other unique advantages that have great potential are the ability to use the EHR and decision support functions to identify patients who qualify for research studies or prescription drug benefits offered by pharmaceutical companies at safety net clinics and hospitals (Embi et al., 2005; Poprock, 2005). Safety net refers to U.S. medical hospitals and clinics that have a mission, legal duty, or obligation to afford health care to individuals irrespective of their ability to pay or health insurance status, thus making all these facilities provide access and care to all the U.S. populations.

The HIMSS Davies Award may be the best resource for combined quantitative and qualitative results of successful EHR implementation. The Davies Award recognizes healthcare organizations that have achieved both excellence in implementation and value from health information technology (HIMSS, n.d.-b; Monegain, 2010). Winners demonstrate a significant avoidance of medication errors, a decrease in medical records expenses, a decrease in adverse drug reactions, and a reduction of duplicate laboratory orders (HIMSS, 2020). There have been qualitative and quantitative evidence of high rates of end user adoption and satisfaction with use of the EHR.

A 2011 study of the effects of EHR adoption on nurse perceptions of quality of care, communication, and patient safety documented that nurses report better care outcomes and fewer concerns with care coordination and patient safety in hospitals with a basic EHR (Kutney-Lee & Kelly, 2011). In this study, nurses perceived that in hospitals with a functioning EHR, there was better communication among staff, especially during patient transfers, and fewer medication errors. Bayliss et al. (2015) demonstrated that an integrated care system utilizing an EHR resulted in fewer hospital readmissions and emergency room visits for over 12,000 seniors with multiple health challenges.

Without an EHR system, any of these benefits would be very difficult and costly to accomplish. Thus, despite limited standards and published studies, there is enough evidence to embrace widespread implementation of the EHR (Halamka, 2006; ONC, 2017a) and certainly enough evidence to warrant further study of the use and benefits of EHRs. **Box 14-2** describes some of the specific CIS functions of an EHR.

BOX 14-2 THE EHR AS A CLINICAL INFORMATION SYSTEM

Denise Tyler

A CIS is a technology-based system applied at the point of care and designed to support care by providing instant access to information for clinicians. Early CISs, implemented before the advent of EHRs, were limited in scope and provided such information as interpretation of laboratory results or a medication formulary and drug interaction information. With the implementation of EHRs, the goal of many organizations is to expand the scope of the early CISs to become comprehensive systems that provide clinical decision support; an electronic patient record; and, in some instances, professional development and training tools. Benefits of such a comprehensive system include easy access to patient data at the point of care; structured and legible information that can be searched easily and lends itself to data mining and analysis; and improved patient safety, especially the prevention of adverse drug reactions and the identification of health risk factors, such as falls.

TRACKING CLINICAL OUTCOMES

The ability to measure outcomes can be enhanced or impeded by the way an information system is designed and used. Although many practitioners can paint a very good picture of the patient by using a narrative (free text), employing this mode of expression in a clinical system without the use of a coded entry makes it difficult to analyze the care given or the patient's response. Free-text reporting also leads to inconsistencies of reporting from clinician to clinician and patient information that is fragmented or disorganized. Such inconsistencies can limit the usefulness of patient data to other clinicians and interfere with the ability to create reports from the data for quality assurance and measurement purposes. Moreover, not all clinicians are equally skilled at the free-text form of communication, which yields inconsistent quality of documentation. Integrating standardized nursing terminologies into computerized nursing documentation systems enhances the ability to use the data for reporting and further research.

According to the IOM (2012), "Payers, healthcare delivery organizations and medical product companies should contribute data to research and analytic consortia to support expanded use of care data to generate new insights" (para. 2). Goldsmith (2019) stated that "many health organizations are already taking advantage of technologies such as AI [artificial intelligence] and advanced analytics to gain insights that help them improve clinical treatment processes and outcomes" (para. 1). Clinical analytics are being used to promote medical care outcomes research. The use of a CIS in conjunction with standardized codes for patient clinical issues helps to support the rigorous analysis of clinical data. Outcomes data produced as part of these analyses may include length of stay, mortality, readmissions, and complications. Future goals include the ability to compare data and outcomes across various institutions as a means of developing clinical or best practices guidelines. With the implementation of a comprehensive CIS, similar analyses of nursing outcomes could also be performed and shared. Likewise, such a system could aid nurse administrators in cross-unit comparisons and staffing decisions, especially when coupled with acuity systems data. In addition, clinical analytics can support required data reporting functions, especially those required by accreditation bodies.

SUPPORTING EVIDENCE-BASED PRACTICE

Evidence-based practice (EBP) can be thought of as the integration of clinical expertise and best practices based on systematic research to enhance decision-making and improve patient care. References supporting EBP, such as clinical guidelines, are available for review at the click of a mouse or the execution of a few keystrokes. The CIS's prompting capabilities can also

reinforce the practice of looking for evidence to support nursing interventions rather than relying on how things have been done historically. This approach enhances processing and understanding of the information and allows the nurse to apply the information to other areas, which increases the knowledge obtained about why certain conditions or responses result in prompts for additional questions or actions.

To incorporate EBP into the practice of clinical nursing, the information needs to be embedded into the computerized documentation system so that it is part of the workflow. The most typical way of embedding this timely information is through clinical practice guidelines. The resulting interventions and clinical outcomes need to be measurable and reportable for further research. The supporting documentation for the EBP must be easily retrievable and meaningful. Links, reminders, and prompts can be used as vehicles for transmission of this information. The format needs to allow for rapid scanning, with the ability to expand the amount of information when more detail is required or desired. Balancing a consistency in formatting with creativity can be difficult but is worth the effort to stimulate an atmosphere for learning.

EBP is supported by translational research, which is an exciting movement that has enormous potential for the sharing and use of EBP. The use of translational research to support EBP may help to close the gap between what is known (i.e., research) and what is done (i.e., practice).

THE CIS AS A STAFF DEVELOPMENT TOOL

Joy Hilty, a registered nurse from Kaweah Delta, devised a creative way to provide staff development and education without taking staff away from the bedside to a classroom setting. She created pop-up boxes on the opening charting screens for all staff who chart on the computer. These pop-ups vary in color and content and include a short piece of clinical information along with a question. Staff can earn vacations from these pop-ups for as long as 14 days by emailing the correct answer to the question. This medium has provided information, stimulation, and a definite benefit: the vacation. The pop-up box education format has also encouraged staff members to share their answers, thereby creating interaction, knowledge dissemination, and reinforcement of the education provided.

Embedding EBP into nursing documentation can also increase the compliance with Joint Commission core measures, such as providing information on influenza and pneumococcal vaccinations to at-risk patients. In the author’s experience at Kaweah Delta, educating staff via classes, flyers, and storyboards was not successful in improving compliance with the documentation of immunization status or offering education on these vaccinations to at-risk patients. Embedding the prompts, information, and related questions into the nursing documentation with a link to the protocol

and educational material, however, improved the compliance to 96% for pneumococcal vaccinations and to 95% for influenza vaccinations (Hettinger, 2007). Downing et al. (2019) studied the implementation of a sepsis alert for inpatients using patient-level randomization and leveraging EHR functionality for real-time alerts along with a patient-centered design in a standardized clinical workflow. They found that even though it is realistic to develop sepsis alerts using the EHR, further research is necessary to comprehend how to design these sepsis alerts to actually change healthcare providers' behavior.

As more information is stored electronically, nurse informaticists must translate the technology so that the input and retrieval of information are developed in a manner that is easy for clinicians to learn and use. A highly usable product should decrease errors and improve information entry and retrieval. Nurse informaticists must be able to work with staff and expert users to design systems that meet the needs of the staff who will actually use the systems. Even after the system has been installed, work continues to develop and improve it because as staff members use it, they will be able to suggest changes to improve it. This ongoing revision should result in a system that is mature and meets the needs of the users.

In an ideal world, all clinical documentation would be shared through a national database, in a standard language, to enable evaluation of nursing care, increase the body of evidence, and improve patient outcomes. With minimal effort, the information would be translated into new research that could be analyzed and linked to new evidence that would be intuitively applied to the CIS. Alerts would be meaningful and specific to patient and provider. The steps required of the clinician to find current, reliable information would be almost transparent, and the information would be presented in a personalized manner, based on user preferences stored in the CIS.

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A more recent description of the benefits of an EHR by the ONC (2022) emphasized that EHRs hold the promise of transforming health care. Specifically, EHRs will lead to the following benefits:

- *Better health care* by improving all aspects of patient care, including safety, effectiveness, patient-centeredness, communication, education, timeliness, efficiency, and equity
- *Better health* by encouraging healthier lifestyles in the entire population, including increased physical activity, better nutrition, avoidance of behavioral risks, and wider use of preventative care
- *Improved efficiencies and lower healthcare costs* by promoting preventative medicine and improved coordination of healthcare services, as well as by reducing waste and redundant tests
- *Better clinical decision making* by integrating patient information from multiple sources (para. 3)

The ONC (2019a) amended the benefits of an EHR that it had listed in 2014. The ONC reminded us in the update that the EHR provides information whenever and wherever it is needed to improve patient care, increase patient engagement, enhance care coordination, and advance diagnostics and patient outcomes with practice efficiencies and cost savings.

The EHR can be an important source of information on patient vulnerability risks related to **social determinants of health (SDOH)**. SDOH are the economic and social conditions, in relation to their diffusion and distribution, among the population that actually influence individual and group differences and disparities in health status and health outcomes; "they are the conditions of the environment in which people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks" (*Healthy People 2030*, n.d., para. 1). SDOH have an effect on our life expectancy, morbidity, and mortality. Paruk (2019) shared that the research has demonstrated that "these factors contribute significantly to health and well-being. For example, average life expectancy is reduced by 15 to 20 years

for people living in low-income communities, due to increased risk for stroke, chronic disease and other health concerns" (para. 2). *Healthy People 2030* (n.d.) stated that there are five key domains for SDOH: "(1) Economic Stability, (2) Education Access and Quality, (3) Health Care Access and Quality, (4) Neighborhood and Built Environment, and (5) Social and Community Context" (para. 1). The eHealth Initiative (2019) provided examples of SDOH that included safe housing and food markets, access to healthcare services, opportunities for recreation, public safety and exposure to crime, and access to emerging technologies.

To gain access to SDOH data, users must be able to extract data found in unstructured text and diagnosis codes as well as what is collected in the EHR. According to Paruk (2019), Allscripts has "discovered more than 2 million SDoH-related diagnoses in our [Allscripts's] data lake of more than 40 million de-identified patient records. Top diagnoses include disruption of family by separation or divorce, disappearance or death of a family member and unemployment" (para. 7). Rohatgi (2022) advocates for the use of specific screening tools to capture SDOH data rather than teasing the information out of data lakes as described above. "While medical care accounts for approximately 20 percent of healthcare, physical environment, socioeconomic factors, and health-related behaviors, all elements of SDOH account for about 80 percent of outcomes" (para. 1). These insights into patients' circumstances can help nurses advocate for them and transform the healthcare delivery system by tailoring services to meet their needs. If nurses can improve the health of individual patients within the population, they will be able to improve the population's health.

Nurses can gather, analyze, and synthesize data and information from each of the SDOH domains. It is imperative that they determine the priorities they must focus on to improve health status. The CMS (2023) developed an Accountable Health Communities model to identify and attend to the SDOH needs that affect healthcare utilization and costs; the model "addresses a critical gap between clinical care and community services in the current health care delivery system" (para. 1). This model is based on emerging

proof that tackling health-related social needs through improved clinical–community relationships can improve health outcomes and decrease costs. According to the CMS (2023), "unmet health-related social needs, such as food insecurity and inadequate or unstable housing, may increase the risk of developing chronic conditions, reduce an individual's ability to manage these conditions, increase health care costs, and lead to avoidable health care utilization" (para. 2). The Accountable Health Communities model is an example of data analytics being used to guide our actions on the data and information that exist at our fingertips. Working collectively with individuals, communities, organizations, the healthcare delivery system, and government agencies, data-driven solutions could be planned, implemented, monitored, and evaluated. If nurses and healthcare professionals can truly act on the data and information to advance health equity, this could restructure social and physical environments to promote better health for everyone.

Standardized Terminology and the EHR

As we inch closer to interoperable EHRs, which provide for seamless health information exchange among providers and healthcare institutions, the need for standardizing terminologies becomes ever clearer. Consider also the trend toward value-based care reimbursements, for which healthcare data are mined "to demonstrate nursing's contributions to improving the cost, quality, and efficiency of care, key elements of the value equation" (Ponte et al., 2016, p. 127). EHR data must be formatted in a machine-readable manner to support interoperable exchange of information and data mining. An important distinction that needs to be made here is the difference between interface terminologies (i.e., North American Nursing Diagnosis Association [NANDA], Nursing Interventions Classification [NIC], and Nursing Outcomes Classification [NOC]) and reference terminologies (i.e., Systematized Nomenclature of Medicine Clinical Terms [SNOMED CT] and Logical Observation Identifiers Names and Codes [LOINC]). It is important to understand the function of the nursing terminologies that interface between nurses' everyday language, used to describe patients and document patient care, and the structured elements of the specific information systems that nurses use. "The mapping of interface terminologies to reference terminologies allows a standard, shared vocabulary to communicate data across settings" (ONC, 2017b, p. 8).

Since the nursing standards support the EHR and nursing practice, the ONC (2017b) assessed the "current state of development and usage within the 12 Standard Nursing Terminologies (SNT) recognized by the American Nurses Association" (p. 4). The ONC conducted a "landscape assessment to better understand the current state and challenges associated with using terminologies and classifications to support nursing practice within health information technology (health IT) solutions" (p. 4). They noted that some health systems found the language in some of the terminologies

awkward and difficult to implement, especially when they are moving "to implement an interdisciplinary care plan and other types of clinical documentation" (p. 23).

The various interface terminologies and their subsets are coded in the EHR and typically presented to the user in drop-down menus. Users may also be able to use a search function in the EHR to identify the most appropriate term that represents the patient's condition. The electronic presentation of these terminologies supports clinician workflow and promotes data retrieval and exchange in future use.

HHS has designated the National Library of Medicine as the central coordinating body for clinical terminologies. (See **Box 14-3** for descriptions of administrative and reference terminologies used in an EHR.) (See Chapter 6, *History and Evolution of Nursing Informatics*, for a list of approved nursing terminologies.) In 2018, the American Nurses Association reaffirmed its support for the use of standardized terminologies:

BOX 14-3 STANDARD EHR ADMINISTRATIVE AND REFERENCE TERMINOLOGIES

ADMINISTRATIVE (BILLING) TERMINOLOGIES

- ICD-10 (International Classification of Diseases, Version 10): Medical diagnosis code set
- CPT (Current Procedural Terminology): Used to code procedures for billing

CLINICAL TERMINOLOGIES

- SNOMED CT (Systematized Nomenclature of Medicine Clinical Terms): Comprehensive clinical terminology (mapping to this terminology is ongoing, including nursing-orders mapping)
- LOINC (Logical Observation Identifier Names and Codes): Universal codes for laboratory and clinical observations
- RxNorm: Terminology system for drug names, which provides links to drug vocabularies and interaction software

- Unified Medical Language System (UMLS) and the Metathesaurus: Support terminology integration efforts and online searches (not a terminology system)

See the National Library of Medicine's website for more comprehensive information: www.nlm.nih.gov/research/umls/Snomed/nursing_terminology_resources.html .

> *The purpose of this position statement is to reaffirm the American Nurses Association's (ANA) support for the use of recognized terminologies supporting nursing practice as valuable representations of nursing practice and to promote the integration of those terminologies into information technology solutions. Standardized terminologies have become a significant vehicle for facilitating interoperability between different concepts, nomenclatures, and information systems.* (para. 1)

Because no single model of standardized terminology for health care or nursing can represent all the contributions to the health of a patient, work is ongoing to map terminologies to one another. For example, Kim et al. (2014) studied the degree of similarity between the International Classification for Nursing Practice (ICNP) and the SNOMED CT. Although they identified some areas of overlap, they cautioned that there is still more work to be done to truly represent nursing concepts in the EHR. Ponte et al. (2016) issued a call to action to chief nursing officers (CNOs): "CNOs must begin partnering with and influencing EHR developers and vendors to ensure the EHRs implemented in their organizations capture nursing content using a standardized taxonomy that is evidence based and mapped to SNOMED-CT and LOINC" (p. 127). Ongoing efforts to map nursing problem lists to SNOMED CT are evident in the work of Matney et al. (2012) and on the National Library of Medicine website (www.nlm.nih.gov/research/umls/Snomed/nursing_terminology_resources.html). It is probably safe to say that the number of types and the variability of EHRs are likely to contract and converge as the demand for robust systems to support interoperability expands. Nurse informatics specialists and CNOs participating in the selection and implementation of EHRs must ask a critical question: To what

extent are nursing care contributions visible, retrievable, and accurately represented in this EHR?

Ownership of Electronic Health Records

The selection and implementation of an EHR has the potential to affect every member of a healthcare organization. The process of becoming a successful owner of an EHR requires multiple steps and integrating the EHR into the organization's day-to-day operations and long-term vision as well as into clinicians' day-to-day practice. All members of the healthcare organization—from the executive level to the clinician at the point of care—must feel a sense of ownership to make the implementation successful for themselves, their colleagues, and their patients. Successful ownership of an EHR may be defined in part by the level of clinician adoption of the tool, and this section reviews key steps and strategies for the selection, implementation, evaluation, and optimization of an EHR in pursuit of that goal.

The first step of ownership is typically a vendor selection process for a certified, commercially available EHR. Although clinicians, as the primary end users, should drive the project, the assessment should also include the needs and readiness of the executive leadership, information technology, and project management teams. In addition, this pre-acquisition phase should concentrate on understanding the current state of the health information technology industry to identify appropriate questions and the next steps in the selection process (American Organization of Nurse Executives, 2009). These first steps begin to identify organizational risks related to successful implementation and pave the way for initiating a change management process to educate the organization about the future state of delivering health care with an EHR system.

The second step of the selection process is to choose a system based on the organization's current and predicted needs. It is common during this phase to see a demonstration of several vendors' EHR products. Based on the completed needs assessment, the organization should establish key evaluation criteria to compare the different vendors and products. These criteria should include

both subjective and objective items that cover such topics as common clinical workflows, decision support, reporting, usability, technical build, and maintenance of the system. Providing the vendor with these guidelines will ensure that the process meets the organization's needs; however, it is also essential to let the vendor demonstrate a proposed future state from its own perspective. This activity is critical to ensuring that the vendor's and the organization's visions are well aligned (Konschak & Shiple, n.d.). It also helps spark dialogue about the possible future state of clinical work at the organization and the change required in obtaining it. Such demonstrations not only enable the organization to compare and contrast the features and functions of different systems but also are a good way to engage the organization's members in being a part of this strategic decision.

Implementation planning should occur concurrently with the selection process, particularly the assessment of the scope of the work, initial sequencing of the EHR components to be implemented, and resources required. However, this step begins in earnest once a vendor and a product have been selected. In addition to further refining the implementation plan, this is the time to identify key metrics by which to measure the EHR's success. An organization may realize numerous benefits from implementing an EHR. It should choose metrics that match its overall strategy and goals in the coming years and may include expected improvements in financial, quality, and clinical outcomes. Commonly used metrics focus on reductions in the number of duplicate laboratory tests through duplicate orders alerting, reductions in the number of adverse drug events through the use of barcode medication administration, **meaningful use** objectives and measures, and the EHR advantages mentioned earlier in this chapter. To ensure that the desired benefits are realized, it is important to avoid choosing so many that they become meaningless or unobtainable and to carefully and practically define those that are selected, measure before and after the implementation, and assign accountability to a member of the organization to ensure that the work is completed.

End user adoption of the EHR is also essential to realizing its benefits. Clinicians must be engaged to use the EHR successfully in their practice and daily workflows so that data may be captured to drive the decision support that underlies so many of the advantages and metrics described. To promote adoption, a change management plan must be developed in conjunction with the EHR implementation plan. The most effective change management plans offer end users several exposures to the system and relevant workflows in advance of its use and continue through the go-live and post-live time periods. Successful pre-live strategies include involving end users as subject matter experts to validate the EHR workflow design and content build, hosting end user usability testing sessions, shadowing end users in their current daily work in parallel with the new system, and conducting formal training activities. The goal of these pre-live activities is not only to ensure that the EHR implementation will meet end users' needs but also to assess the effect of the new EHR on current workflow and processes. The larger the effect, the more change management is required above and beyond system training. For example, simulation laboratory experiences may be offered to more thoroughly rehearse a significant workflow change; executive leaders may need to convey their support and expectations of clinicians about a new way of working; and, generally, more anticipatory guidance is required to communicate to those affected by the changes.

Training may be delivered in a variety of media. Often, a combination of approaches works best, including classroom time; electronic learning; independent exercises; and peer-to-peer, at-the-elbow support. Training must be workflow based and reflect real clinical processes. It must be planned and budgeted for through the post-live period to ensure that competency with the system is assessed at the go-live point and any necessary retraining or reinforcements are made in the 30 to 60 days post-live. This process not only promotes reliability and safe use of the system as it was designed but also can have a positive effect on end users' morale; users will feel that they are being supported beyond the initial go-

live period and have an opportunity to move from basic skills to advanced proficiency with the system.

Finally, the implementation plan should account for the long-term optimization of the EHR. This step is commonly overlooked and often results in benefits falling short of expectations because the resources are not available to realize them permanently. It also often means the difference between end users of EHRs merely surviving the change versus becoming savvy about how to adopt the EHR as another powerful clinical tool, much as clinicians have embraced such technologies as the stethoscope (ONC, 2017a). Optimization activities of the EHR should be considered a routine part of the organization's operations and resourced accordingly and should emphasize the continued involvement of clinician users to identify ways that the EHR can enable the organization to achieve its overall mission. Many organizations start implementations of EHRs with the goal of transforming their care delivery and operations. An endeavor that differs from simply automating a previously manual or fragmented process, transformation often includes steps to improve the process to realize better patient care outcomes or added efficiency. Although some transformation is experienced with the initial use of the system, most of this work is done after implementation and relies on widespread clinician adoption of the EHR. As such, it makes optimization a critical component to successful ownership of an EHR.

Flexibility and Expandability

Health care is as unique as the patients themselves. It is delivered in a variety of settings, for a variety of reasons, over the course of a patient's lifetime. In addition, patients rarely receive all their care from one healthcare organization; indeed, choice is a cornerstone of the U.S. healthcare system. An EHR must be flexible and expandable to meet the needs of patients and caregivers in all these settings, despite the challenges.

At a very basic level, there is as yet no EHR system available that can provide all functions for all specialties to such a degree that all clinicians would successfully adopt it. Consider oncology as an example. Most systems do not yet provide the advanced ordering features required for the complex treatment planning undertaken in this field. An oncologist could use a general system, but they would not find as many benefits without additional features for chemotherapy ordering, lifetime cumulative dose tracking, or the ability to adjust a treatment day schedule and recalculate a schedule for the remaining days of the plan. Some EHRs do a good job of supporting the work of nursing staff and physicians but are not as supportive of the work of clinicians, such as dieticians, physical and occupational therapists, and other healthcare personnel. These systems will continue to evolve and support interprofessional collaboration as more healthcare professionals are exposed to the power of these systems to support their work and become better able to articulate their specific needs.

Conditions are improving every day at both vendor and healthcare organizations alike. Some improvements were recently fueled by ARRA incentives (see **Box 14-4**).

BOX 14-4 CLOUDY EHRS

A paradigm shift from healthcare facility–owned, machine-based computing to off-site, vendor-owned cloud computing with web browser–based, log-on–accessible data, software, and hardware could link systems together and reduce costs. Hospitals with shrinking budgets and extreme IT needs are exploring the successes in this area achieved in other industries, such as Amazon's S3. As providers strive to implement potent EHRs, they are looking for cloud-based models that offer the necessary functionality without having to assume the burden associated with all the hardware, software, application, and storage issues. However, in the face of the HITECH Act and its associated penalties, how can nurses and healthcare professionals overcome the challenges to realize the benefits of this approach? Cloud computing has both advantages and disadvantages, and while healthcare providers explore this new paradigm, they must relinquish control as they continue to strive to maintain security. The vendors that are responsible for developing and maintaining this new environment are also facing challenges originating from both legislatures and healthcare providers. As the vendors and healthcare providers work together to improve the implementation and adoption of the cloud-based EHR, the sky is the limit!

ARRA has also set the expectation that despite the large number of settings in which a patient may receive care, a minimum set of data from those records must flow, or "interoperate," among each setting and the unique EHR systems used in those settings. Today, interoperability exists through what is called a Continuity of Care Document (CCD). This data set includes information about a patient's health care, such as patient demographics, medications, allergies, and problems. The document is formatted according to HL7 standards and is both machine and human readable.

Despite this positive step forward, financial and patient privacy hurdles remain to be overcome to achieve an expansive EHR. Most health care is delivered by small community practices and hospitals, many of which do not have the financial or technical resources to implement robust, interoperable EHRs. HHS recently loosened regulations so that physicians may now be able to receive healthcare information technology software, hardware, and implementation services from hospitals to alleviate the financial burden placed on individual providers and foster more widespread adoption of the EHR. Interoperable EHRs facilitate data sharing to help "coordinate care, reduce costs, manage population health, improve patient

experience and outcomes, and address health equity challenges" (Juhn & Galvez, 2022, p. 426).

Accountable Care Organizations and the EHR

EHRs with data-sharing capabilities are central to the support of Accountable Care Organizations (ACOs), a payment incentive program established by the CMS (2022). As discussed elsewhere, this program of shared medical and financial responsibility is designed to provide quality, coordinated care while limiting costs. Some of the core information technology requirements for an ACO are EHRs, HIEs, care management systems, and analytics and reporting systems (Welter, 2015; **Figure 14-2**). A robust EHR can support many of these functions:



Data from: ECG Consultants. (2015). *The use of technology in healthcare reform: IT considerations for accountable care.* www.ecgmc.com/thought-leadership/articles/the-use-of-technology-in-healthcare-reform-it-considerations-for-accountable-care.

Figure 14-2 How EHRs Support Accountable Care

Description

EHR solutions that are interoperable across organizations can significantly reduce the cost and complication of IT infrastructure by creating full EHR visibility between providers. This shared visibility reduces or eliminates the need to participate in HIEs or invest in solutions to integrate data across different EHR platforms. Many EHRs also can serve as a program's care management system, eliminating the need for a separate system to document care management efforts and help care teams engage with patients. (Welter, 2015, para. 5)

The Future

Despite the challenges, the future of EHRs is an exciting one for patients and clinicians alike. Benefits may be realized by implementing stand-alone EHRs, as described here, but the more significant transformation will come as interoperability is realized between systems.

The U.S. population depends on health IT to "securely, efficiently, and effectively share electronic health information with patient consent to achieve better care, smarter spending and healthier people" (ONC, 2019b, para. 1). The barriers that must be eliminated are the lack of confidence and trust in the healthcare delivery system, lack of standardized health information, payment and reimbursement issues, and the fact that privacy laws are not standard and can lead to misinterpretation (ONC, 2019b, para. 2). Patients and healthcare providers must continue to fight to overcome the barriers to interoperability because it has the potential to truly transform our healthcare delivery system "from a static one to a learning health system that improves individual, community and population health" (ONC, 2019b, para. 1).

The future also holds tremendous potential for EHR features and functions that will include not only more sophisticated decision support and clinical reporting capacity but also improved support for patients and all healthcare professionals; improved biomedical device integration, ease of use, and intuitiveness; and access through more hardware platforms (see the Applications: Enhancing the EHR box).

Implementation of robust and interoperable EHRs is becoming more commonplace. As more organizations adopt EHRs, broader dissemination of implementation best practices will be facilitated, with the hope of further shortening the time required to take advantage of advanced EHR features.

APPLICATIONS: ENHANCING THE EHR

ARTIFICIAL INTELLIGENCE (AI)

Siwicki (2019) reported on Vanderbilt's AI-powered EHR voice assistant. This "VEVA tool has helped improve caregiver productivity and efficiency" (para. 1). Healthcare providers can interact with the EHR using their voice through natural speech recognition. Using AI is valued because it saves time by decreasing the number of clicks per query.

PATIENT ENGAGEMENT

The ONC (2023) stated that we should realize the opportunity to engage patients in their health and care by using and expanding EHR patient portals. The patient portals have the ability to streamline and simplify clinical workflows while improving patient engagement by meeting patients' needs. You could provide the ability to schedule an appointment or reorder prescription refills, thereby drawing your patients to the EHR portal.

BLOCKCHAIN

Carfagno (2018) reminded us of the fragmented medical records in health care across multiple providers and how healthcare professionals could miss important patient information. Blockchain technology is a secure technology that could cure this transactional inefficiency and bring all these pieces of information concerning a patient together so that all the records are in sync all the time. Blockchain is being implemented in the Mayo Clinic EHR. Because blockchain technologies enhance EHRs, they can streamline processes, such as associating or connecting patients with their EHR information to activate insurance reimbursement payments related to a specific disease process without having to reverify the diagnosis or file a claim. This process could also expedite the filling of a prescription because all the information would be available, including whether this drug is the best drug, the insurance benefit related to what the company will cover, and even so far as to make sure that the pharmacy is able to provide the patient with the specific drug that was ordered. As an example of one transactional inefficiency that could be addressed through blockchain technology, think of insurance, a resource-intensive area. With blockchain technology, the physician's office staff would not need to know every insurance plan's benefits or make numerous calls to find out, and the patient would not have to play the waiting game to see whether the drug is approved and available.

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In the future, we can expect to see more enhanced EHRs housed in the cloud, usable patient portals as we move toward more patient-centered health care, the integration of wearables and data into the EHR, the expansion of telemedicine applications for rural patients and those with chronic illnesses, precision medicine advances supported by data analytics, integration of both care and wellness plans, and better consumer engagement, making the care plan a living document (Sterrett et al., 2022).

Summary

It is an important time for health care and technology. EHRs are evolving to include SDOH, AI, blockchain, and patient engagement strategies. EHRs will remain central to shaping the future of health care. In an ideal world, all nurses, from entry-level personnel to executives, would have a basic competency in nursing informatics, which would enable them to participate fully in shaping the future use of technology in the practice at a national level and wherever care is delivered. Such initiatives as Technology Informatics Guiding Education Reform (TIGER) and the important nursing terminology work are imperative for better integration and, ultimately, more visibility of nursing contributions to health care (HIMSS, n.d.-d).

THOUGHT-PROVOKING QUESTIONS

1. What are the implications for nursing education in relation to preparing nursing students to leverage the EHR in caring for patients, communicating with other healthcare professionals, decision-making, and research?
2. What are the ethical considerations related to interoperability and a shared EHR?
3. What are the SDOH? Describe in detail the areas of the EHR where the SDOH would be captured. In your description, make sure to detail the data and information. State whether the data would be structured or unstructured and how meaningful SDOH information could be extracted.
4. You are asked about a diagnosis with which you are unfamiliar. Where would you start looking for information? How would you determine the validity of the information?
5. Think about the documentation and knowledge management functions of your specialty. If you had the opportunity to create a wish list, what would you include in an EHR to support your work?
6. Reflect on EHRs. Describe in detail how an EHR engages healthcare providers. How can it engage a patient? Provide a comprehensive rationale

for each way you determine you could use the EHR to engage your patient.

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CHAPTER 15

Informatics Tools to Promote Patient Safety, Quality Outcomes, and Interdisciplinary Collaboration

OBJECTIVES

1. Explore the characteristics of and strategies for developing a safety culture.
2. Appreciate the effect of informatics technology on patient safety.
3. Recognize how human factors contribute to patient safety and errors.
4. Explore interdisciplinary collaboration and communication in relation to patient safety.

KEY TERMS

- adverse event
- Agency for Healthcare Research and Quality (AHRQ)
- alarm fatigue
- application (app)
- barcode medication administration (BCMA)
- clinical decision support (CDS)
- computerized provider order entry (CPOE)
- electronic medication administration system (eMAR)

- failure modes and effects analysis (FMEA)
- Government Accountability Office (GAO)
- high-hazard drug
- human factors engineering
- interdisciplinary collaboration
- interprofessional collaboration
- just culture
- never event
- radio-frequency identification (RFID)
- root-cause analysis
- safety culture
- sentinel event
- smart pump
- smart room
- systems engineering
- wearable technology
- workaround

Introduction

Nursing professionals have an ethical duty to ensure patient safety. According to Lavin et al. (2015), "Direct care nurses, at their core, are risk managers. They attach meaning to what is and anticipate 'what might be'" (para. 8). As the media and patients circulate stories about the lack of safety in healthcare institutions, it is no wonder that healthcare consumers are skeptical and providers are wary. A study out of Johns Hopkins University (McMains, 2016) suggested that medical errors are the third-leading cause of death in the United States. Versel (2016) reminded us, however, that "it's not the first time someone has called medical error the No. 3 cause of death in the U.S. John T. James, founder of a group called Patient Safety America, did that in a 2013 report in the *Journal of Patient Safety*" (para. 2). The World Health Organization (2019) offered this perspective: "It is estimated that there is a 1 in 3 million risk of dying while travelling by airplane. In comparison, the risk of patient death occurring due to a preventable medical accident, while receiving health care, is estimated to be 1 in 300" (para. 1). In 2022, Wilsonlaw.com outlined 10 medical errors that can lead to patient deaths, many of which can be addressed by informatics and technology. They include communication issues, information flow issues, medication errors, poor organizational transfer of knowledge, misdiagnosis, delayed diagnosis, patient identification and assessment issues, staffing and workflow issues, medical equipment malfunctions, and inadequate organizational policies.

Increasing demands on professionals in complex and fast-paced healthcare environments may lead them to cut corners or develop workarounds that deviate from accepted and expected practice protocols. These deviations are not carried out deliberately to put patients at risk but rather are often practiced in the interest of saving time or preserving a usual workflow or because the organizational culture is such that risky behaviors are commonplace. Occasionally, these inappropriate actions or omissions of appropriate

actions result in harm or significant risk of harm to patients. The Patient Safety Network (2022) outlined the issues created by the COVID-19 pandemic and emphasized the additional safety risks for both patients and healthcare workers. During infection surges, we faced shortages of ventilators, catheters, and personal protective equipment (PPE) supplies. Typical unit workflows, staffing (staff were infected), and communication (wearing PPE) were disrupted. In addition, ventilated patients were placed in the prone position to support lung function, and skin integrity was compromised in unusual places. Some patients also developed additional infections while hospitalized, which further compromised their illness trajectory. "As more data become available, highlighting where innovative approaches were successful at reducing the risk of adverse events during the pandemic, researchers and policymakers will need to determine if there are particular best practices that may be suitable for continued use beyond the pandemic" (para. 9).

A safety issue that results in death, permanent harm, or serious temporary harm that requires intervention is termed a **sentinel event** by the Joint Commission (n.d.). In 2013, the sentinel event definition was expanded to include safety issues involving anyone on the institution's premises (Patra & De Jesus, 2022). Consider the following case scenario:

> *A patient being treated for a potential pulmonary embolism was inadvertently given over 17,000 units of heparin because a smart pump was mis-programmed to run at 1,000 ml per hour rather than 1,000 units per hour (20 ml).* (Institute for Safe Medication Practices, 2007)

The smart pump used in this scenario was equipped with dose-calculation software that compares the programmed infusion rate to a drug database to check for dosing within safe limits. This is an example of a knowledge-based clinical decision support system, which is discussed later in this chapter. This technology is particularly important when high-alert drugs, or **high-hazard drugs**, are being administered. In this case, however, the available dose-checking technology had been turned off, and the pump was operated in standard, rather than smart, mode. A subsequent analysis of the

error event revealed that, to save time, many nurses in the institution were bypassing the safety technology afforded by the smart pump. Even though it has been quite some time since this error occurred, we continue to see alerts and safety checks being worked around, ignored, or turned off. This chapter focuses on some of the recommended organizational strategies used to promote a culture of safety and some of the specific informatics technologies designed to reduce errors and promote patient safety. Safety is everyone’s responsibility.

What Is a Culture of Safety?

The 2000 Institute of Medicine's report *To Err Is Human* is widely credited for launching the current focus on patient safety in health care. This report was followed in 2001 by the Institute of Medicine's report *Crossing the Quality Chasm*, which brought to national attention healthcare quality and safety. This national attention resulted in a $50 million grant by Congress to the **Agency for Healthcare Research and Quality (AHRQ)** to launch initiatives focused on safety research for patients. Other initiatives prompted by these seminal reports were the Joint Commission's National Patient Safety Goals (updated yearly since 2002), the National Quality Forum's adverse events and **never events** list (2002), the creation of the Office of the National Coordinator for Health Information Technology (ONC) to computerize health care (2004), the formation of the World Health Organization's Alliance for Patient Safety (2004), the Institute for Healthcare Improvement's (IHI's) 100,000 Lives campaign (2005) and 5 Million Lives campaign (2008), congressional authorization of patient safety organizations created by the Patient Safety and Quality Improvement Act to promote blameless error reporting and shared learning (2005), the "no pay for errors" initiative launched by Medicare (2008), and the $19 billion congressional appropriation to support electronic health records (EHRs) and patient safety (Wachter, 2010). In 2013, the Patient Safety Movement Foundation launched the Open Data Pledge and later announced three new patient safety challenges in 2016 (Patient Safety Movement, 2016). The most pressing challenges it identified —venous thromboembolism, mental health, and pediatric adverse drug events—reflect those in which patient death could be prevented with the proper protocols in place during the provision of patient care.

The AHRQ (2019) **safety culture** primer suggested that organizations should strive to achieve high reliability by being committed to improving healthcare quality and preventing medical

errors and demonstrating an overall commitment to patient safety; that is, everyone and every level in an organization must embrace the safety culture. Key features of a safety culture identified by the AHRQ are as follows:

- Acknowledgment of the high-risk nature of an organization's activities and the determination to achieve consistently safe operations
- A blame-free environment where individuals can report errors or near misses without fear of reprimand or punishment
- Encouragement of collaboration across ranks and disciplines to seek solutions to patient safety problems
- Organizational commitment of resources to address safety concerns (para. 1)

The Committee on Patient Safety and Education of the American Society of Anesthesiologists (2022) emphasized that "[o]rganizations with strong safety cultures are not characterized by a complete absence of adverse events, but by their commitment to capturing and responding to these events, recognizing how each one gives valuable insight for further system improvement. Unsafe cultures, in contrast, can be highlighted by a lack of trust, fear of speaking up, absence of transparency, incivility, or even workplace violence" (para. 2).

An important part of the safety culture is cultivating a blame-free environment. Errors and near misses must always be reported so that they can be thoroughly analyzed to ascertain changes needed to prevent reoccurrence. All organizations can learn from mistakes and change their organizational processes or culture to ensure patient safety. These critical points are reiterated in a recent Sentinel Event Alert released by the Joint Commission (2018). The Patient Safety and Quality Improvement Act of 2005 mandated the creation of a national database of medical errors and funded several organizations to analyze these data with the goal of developing shared learning to prevent medical errors. Organizations themselves

can engage in **root-cause analysis** or **failure modes and effects analysis (FMEA)**, both of which are systems analyses to examine medical errors closely to determine the system processes that need to be changed to prevent similar future errors (Harrison & Daly, 2009; Patient Safety Network, 2019c). A tool for implementing root-cause analysis, which was developed by the U.S. Department of Veteran's Affairs National Center for Patient Safety (n.d.), had three goals: to determine "what happened, why did it happen and how to prevent it from happening again" (para. 4). Everyone is encouraged to submit actual medical errors and/or patient safety issues to the Patient Safety Network (n.d.). Similarly, the IHI has a website dedicated to FMEA. "Failure Modes and Effects Analysis (FMEA) is a systematic, proactive method for evaluating a process to identify where and how it might fail, and to assess the relative impact of different failures in order to identify the parts of the process that are most in need of change" (IHI, n.d.-b, para. 1). This powerful tool can be viewed at www.ihi.org/resources/Pages/Tools/FailureModesandEffectsAnalysisTool.aspx. The discussion accompanying the systems approach advocated by the Patient Safety Network (2019c) emphasized "that most errors reflect predictable human failings in the context of poorly designed systems (e.g., expected lapses in human vigilance in the face of long work hours or predictable mistakes on the part of relatively inexperienced personnel faced with cognitively complex situations)" (para. 2).

If one embraces a blame-free environment to encourage error reporting, then where does individual accountability fit in? According to the AHRQ (2019), one way to balance these competing cultural values (blameless vs. accountability) is to establish a **just culture** in which system or process issues that lead to unsafe behaviors and errors are addressed by changing practices or workflow processes and a clear message is communicated that reckless behaviors are not tolerated. The just culture approach accounts for three types of behaviors that lead to patient safety compromises: (1) human error (i.e., unintentional mistakes), (2) risky behaviors (i.e., workarounds), and (3) reckless behavior (i.e., total disregard for established policies

and procedures). The Joint Commission (2018) indicated that to encourage reporting in a just culture, leadership must use accountability assessment tools to distinguish between human error and reckless behavior: "Leadership must gradually change the culture so that the need to report and do something about a safety issue outweighs the fear of being punished" (para. 11).

Strategies for Developing a Safety Culture

Strategies for achieving a safety culture have been addressed frequently in the literature and embraced by several key organizations. The focus here is limited to those strategies described by three key organizations: the AHRQ, the Joint Commission, and the IHI. The AHRQ (2016), based on data from the Hospital Survey on Patient Safety Culture, suggested that teamwork training, executive walk-arounds, and unit-based safety teams have improved safety culture perceptions but have not led to a significant reduction in error rates. The AHRQ recommended seven steps for action planning: "1. Understand your survey results. 2. Communicate and discuss survey results. 3. Develop focused action plans. 4. Communicate action plans and deliverables. 5. Implement action plans. 6. Track progress and evaluate impact. 7. Share what works" (p. 61). Informatics can assist with the analysis, trending, synthesis, and dissemination of the action plan results. In 2020, the AHRQ released a report titled "Making Healthcare Safer III." In this report, 47 patient safety practices in high-risk healthcare areas were reviewed, using a conceptual framework that "(1) puts the patient in the center; (2) acknowledges that patients are constantly exposed to potential harms; and (3) proposes patient safety approaches that mitigate patients' past and future vulnerabilities" (para. 3). Access an overview of the report here and then follow links to specific safety topics: www.jointcommission.org/standards/national-patient-safety-goals/hospital-national-patient-safety-goals/. The IHI (n.d.-a) stressed that organizational leaders must drive the culture change by making a visible commitment to safety and enabling staff to share safety information openly. Some of the strategies suggested by the IHI include appointing a safety champion for every unit, creating an adverse event response team, and reenacting or simulating adverse events to better understand the organizational or procedural processes that failed. The IHI (Frankel et al., 2017) released a white paper titled "A Framework for Safe, Reliable, and Effective Care,"

which emphasized the organizational culture, the need to establish a learning system, and patient engagement as cornerstones of safety. Access the paper here: www.ihi.org/resources/Pages/IHIWhitePapers/Framework-Safe-Reliable-Effective-Care.aspx.

Leadership oversight and support are critical to ongoing sharing about errors; near misses; and, most importantly, collaborative solution development to provide safe care and achieve quality outcomes for all patients. Radick (2016) believed that senior leaders must be involved to sustain patient safety improvements. The importance of leadership in a safety culture was emphasized by the Joint Commission (2018). Leaders understand "that systemic flaws exist and each step in a care process has the potential for failure simply because humans make mistakes" (para. 1). In the same Sentinel Event Alert, three characteristics of a safety culture were emphasized:

- Just culture: People are encouraged, even rewarded, for providing essential safety-related information, but clear lines are drawn between human error and at-risk or reckless behaviors.
- Reporting culture: People report their errors and near misses.
- Learning culture: People are willing and competent to draw the right conclusions from safety information systems and willing to implement major reforms when their need is indicated.

Ways must be found to encourage people to report errors, near misses, and good catches so that systems and processes can be reviewed and improved and people can learn from errors. Carmack and Valleru (2022) emphasized the importance of speaking up when a safety concern or issue is observed. "The act of speaking up is not automatic; it will occur when there is intentional support from nursing leaders and medical staff members to remove barriers and enhance trust, which is critical for success with speaking up and stopping the line for safety" (p. 352).

Each year, the Joint Commission releases Hospital National Patient Safety Goals. The 2023 goals center around patient identification, staff communications, medication use, alarms, infection prevention, identifying patients at risk for suicide, and prevention of surgical mistakes. Access the 2023 version at this site: www.jointcommission.org/-/media/tjc/documents/standards/national-patient-safety-goals/2023/2023-hap-npsg-goals-102122_simple.pdf. For a comprehensive look at global strategies for safety in health care, access the World Health Organization's Global Patient Safety Action Plan 2021–2030: www.who.int/teams/integrated-health-services/patient-safety/policy/global-patient-safety-action-plan. The safety literature is clearly converging to emphasize culture, reporting, patient and family engagement, and learning.

Human Factors and Systems Engineering

We turn now to safety initiatives more specifically related to technology. A **systems engineering** approach to patient safety, in which technology manufacturers partner with organizations to identify risks to patient safety and promote safe technology integration, was advocated by Ebben et al. as early as 2008. They noted that **human factors engineering** is "[t]he discipline of applying what is known about human capabilities and limitations to the design of products, processes, systems, and work environments" and its application to system design improves "ease of use, system performance and reliability, and user satisfaction, while reducing operational errors, operator stress, training requirements, user fatigue, and product liability" (p. 327). For example, Ebben et al. described the feel of an oxygen control knob that rotated smoothly between settings, which suggested to the user that oxygen flows at all points on the knob, when in fact oxygen flowed only at specifically designated liter flow settings. Human factors engineering testing would most likely reveal this design flaw, and the setting knob could be improved to include discrete audio or tactile feedback (click into place) to the user to indicate a point on the dial where oxygen flows. Ebben et al. also emphasized that testing human use factors provides more objective safety data than the subjective responses gained from user preference testing. "Understanding how the equipment shapes human performance is as important as evaluating reliability or other technical criteria" (p. 329). A World Health Organization (2016) publication makes an important point about human factors engineering: "The overall human factors philosophy is that the system should be designed to support the work of people, rather than designing systems to which people must adapt" (p. 5). Further, this publication cautions that issues with information and information chaos contribute to safety incidents because clinicians are overwhelmed with information. It defined information chaos as follows:

- Information overload (i.e., too much unnecessary information)
- Information underload (i.e., missing or not enough information)
- Information scatter (i.e., information located in many different places and difficult to find)
- Erroneous or conflicting information (p. 6)

Organizations that are purchasing medical technology devices should avail themselves of shared safety data on equipment maintained by several key organizations, including the Joint Commission, the U.S. Food and Drug Administration (FDA), and the Medical Product Safety Network (www.fda.gov/medical-devices/medical-device-safety/medsun-medical-product-safety-network). Many healthcare practitioners feel that we have not made great strides in either sharing our data or accessing the available data to enhance patient safety interests. According to the WISH Patient Safety Forum (Pronovost et al., 2015), the patient safety premises that harms are inevitable, data silos (rather than shared data) are natural, and heroism is the norm "have inadvertently provided excuses for not addressing patient safety comprehensively" (p. 9). This forum also stated the following:

> *The belief that data silos are acceptable in healthcare settings is an irresponsible view regarding the role of data; it lacks an understanding of the current operational setting. Healthcare is a complex, multidisciplinary environment that requires collaboration and sharing of data across an integrated stakeholder community.* (p. 9)

As health information technology (IT) evolves and is refined, it continues to improve patient safety. Banger and Graber (2015) stated the following:

> *ONC is involved in a number of initiatives in support of this goal, including plans for a new national Health IT Safety Center to coordinate these efforts. Combined with the active engagement from the private sector, there is every reason to be optimistic that health IT will continue to improve the quality and safety of health care beyond the accomplishments realized to date.* (p. 10)

According to the Patient Safety Network (2019b), "busy health care workers rely on equipment to carry out life-saving interventions, with the underlying assumption that technology will improve outcomes" (para. 2). The Patient Safety Network provided the following descriptions of equipment issues:

> *An obstetric nurse connects a bag of pain medication intended for an epidural catheter to the mother's intravenous (IV) line, resulting in a fatal cardiac arrest. Newborns in a neonatal intensive care unit are given full-dose heparin instead of low-dose flushes, leading to three deaths from intracranial bleeding. An elderly man experiences cardiac arrest while hospitalized, but when the code blue team arrives, they are unable to administer a potentially life-saving shock because the defibrillator pads and the defibrillator itself cannot be physically connected.* (para. 1)

Once the technology is integrated into the organization, biomedical engineers can become valuable partners in promoting patient safety through appropriate use of these technologies (**Figure 15-1**). For example, in one organization, the biomedical engineers helped to revamp processes associated with the new technology alarm systems after they discovered several key issues: slow response times to legitimate alarms and multiple false alarms (promoting **alarm fatigue**) created by alarm parameters that were too sensitive. Strategies for addressing these issues included improving the nurse call system by adding Voice over Internet Protocol telephones, which wirelessly receive alarms directly from technology equipment carried by all nurses, thus reducing response times to alarms; feeding alarm data into a reporting database for further analysis; and encouraging nurses to round with physicians to provide input into alarm parameters that were too sensitive and generating multiple false alarms (Joint Commission, 2013; Schlabig Williams, 2009).

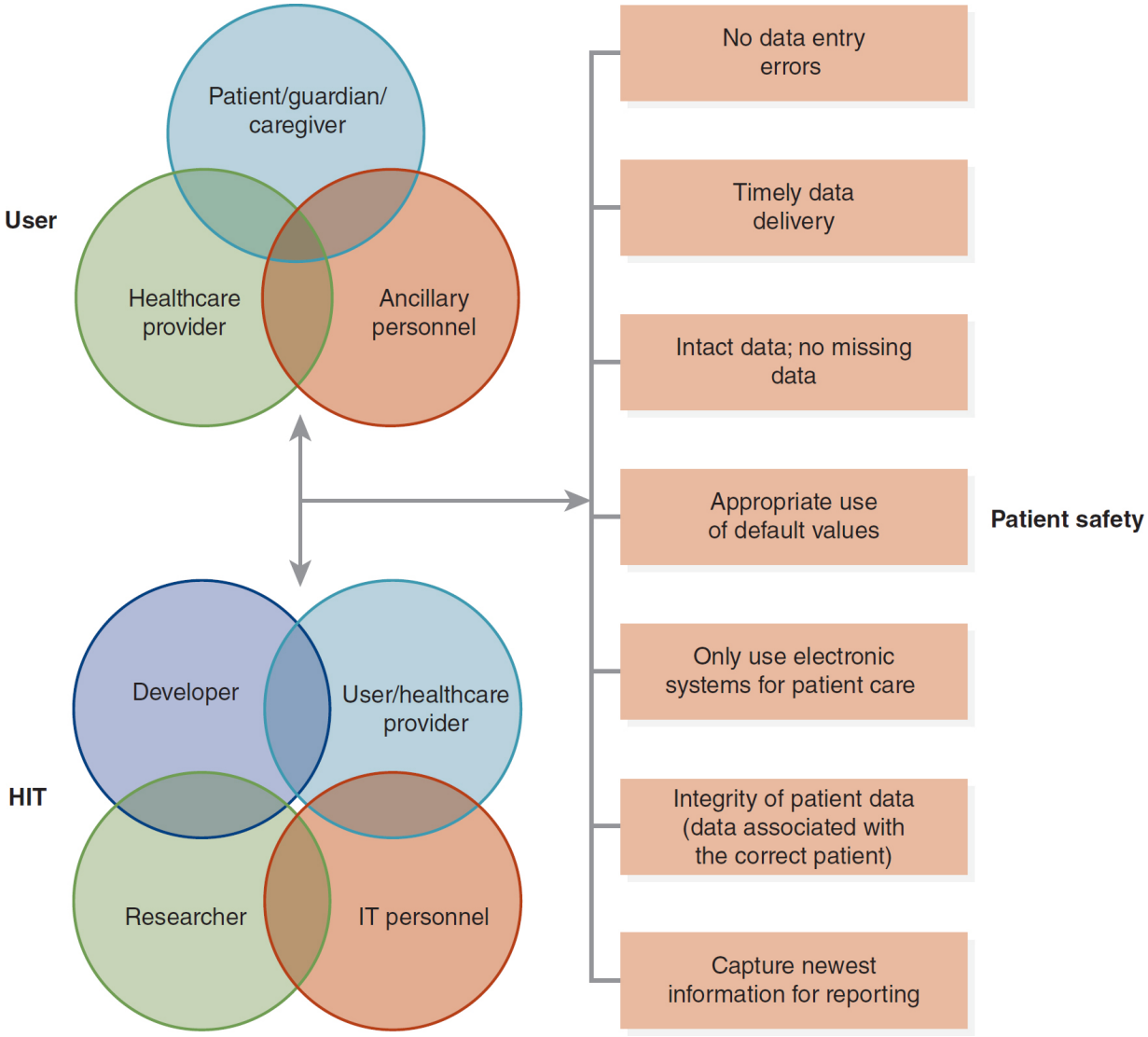


Figure 15-1 User–Technology–Patient Safety Scheme

Description

The case scenario, Well-Intentioned Providers, demonstrates how well-intentioned healthcare providers can cause harm. An audit conducted by Philips Healthcare (2013) at one of its customer sites revealed the following:

> *[A] Telemetry Charge Nurse was found to be receiving and responding to an average of 3.7 alarms per minute over the duration of the audit. Even allowing for minimal time to respond to each alarm, it is clear that this situation was problematic. A majority of that nurse's time was spent responding to alarms, and inevitably some were missed.* (para. 1)

Goal 4 of the 2023 Hospital National Patient Safety Goals of the Joint Commission is "Make improvements to ensure that alarms on medical equipment are heard and responded to on time" (para. 4). Interestingly, this goal first appeared in the 2014 edition and has been included every year since then. Many patient monitoring and medication administration technologies are equipped with alarms to alert caregivers of potential problems. At issue is the number of alarms, especially false alarms caused, for example, by artifact or patient movement. Multiple false alarms can lead caregivers to become desensitized so that they ignore or even turn off alarm systems. Some strategies suggested by the Joint Commission include developing policies and procedures to establish who can set or change alarm parameters, when an alarm can be disabled, and who is responsible for responding to alarms.

CASE SCENARIO: WELL-INTENTIONED PROVIDERS

Even well-intentioned healthcare providers can cause harm. Consider what should have been done differently in the following case scenario.

Laura, a 25-year-old woman, arrived at the ER complaining of chest pain. She has two young children at home, a 6-year-old boy and a 4-year-old girl. She stated that she has been experiencing severe fatigue and fluttering in her chest for weeks but felt that she needed rest and it was probably nothing. Today, she had the fluttering with chest pain, and even her teeth and jaw hurt. This scared her, so she decided to go to the hospital. However, she had to wait 2 hours for her mother to arrive to watch the children. Her husband is on a business trip and will not be returning for 4 days. The initial ECG revealed normal sinus rhythm, and all lab values were normal. The emergency room physician decided to keep her for observation and sent her to the telemetry unit.

Laura was moved to telemetry and, as she stated, "wired for sound." The nurse described the equipment and told her that in addition to all of the monitoring equipment, they would check her vital signs every hour as well. The nurse no sooner returned to the nurse's station when Laura's cardiac monitor alerted her that Laura was experiencing severe

bradycardia (i.e., heart rate of less than 40 beats per minute). When the nurse arrived at Laura's bedside, she found Laura sound asleep. She woke her gently and told her that her monitor was alarming and that she was going to check her. Laura stated that she felt tired and was enjoying the peaceful sleep. Laura's vital signs were fine and her heart rate was 72 beats per minute. The nurse reset the monitor, by which point Laura had already fallen back to sleep. The monitor alarmed the same way three more times within the next hour. Each time, the nurse woke Laura and everything was fine. The nurse decided to contact the resident. While she was waiting for the resident, it alarmed twice again, but she just reset it and let Laura sleep. The resident came and examined Laura. The resident felt everything was OK and that this young mother needed her rest. The resident suggested that the nurse stop the hourly vitals; call and have the equipment examined by the biomedical department; and, in the meantime, turn the alarm off. The nurse agreed, turned off the alarm, placed a call to the biomedical technician on duty, and left a message.

The nurse had another patient who also had frequent alarms, but his corresponded to actual medical events. As a result, the nurse was spending a great deal of time with this elderly gentleman and his wife. Each time she walked by Laura's bed, the nurse noted that Laura was sleeping. She realized that it had been 2 hours since she had turned off the alarm and called the biomedical technician, so she decided to check on Laura; however, her other patient's alarm went off, and since Laura was sleeping, the nurse went to the other patient's bedside. At 4 hours after the alarm had been turned off, the biomedical technician arrived and apologized because one of the other techs called off sick in their department and they were shorthanded. The nurse explained what had happened, and the biomedical technician went to check Laura's monitoring equipment. The biomedical technician called for the nurse because the patient was unresponsive. The nurse could not wake Laura, and the monitor was showing asystole. A code was initiated, and Laura was pronounced dead 5 hours after she had arrived on the telemetry unit.

This situation was assessed by the patient safety officer and the patient safety committee. Their determination was that because the monitor was integrated and all functions ran through the same controller, the nurse did not realize she was turning off all of the monitors (e.g., pulse oximetry and blood pressure). This situation was found to be an issue with the equipment itself because the alarm settings are too close together and not clearly labeled; however, the nurse should never have turned the alarms off. With the hourly checks canceled and all the monitoring equipment silenced, Laura was not being monitored at all.

Well-intentioned providers were allowing this young mother to sleep but with fatal consequences.

It is evident from the case scenario that we have yet to find a solution to the problem of alarm fatigue and related issues that negatively affect patient safety.

Clearly, there is more work to be done to create safety cultures in complex healthcare organizations and to reduce the incidence of errors. Many organizations are looking to informatics technology to help manage these complex safety issues by using smart technologies that provide knowledge access to users and automated safety checks and that improve communication processes. Harrison (2016) stated that "as nurse leaders in a clinical setting where smart tools are leveraged to increase the quality and safety of patient care, we have certain responsibilities to ensure safe implementation, training, and monitoring" (p. 21). To best utilize the available technology, nurse leaders and administrators must be able to use data. More and more graduate programs for nursing administrators are realizing the need for these emerging nursing leaders to be skilled in nursing informatics. These leaders must be able to use data, information, and knowledge efficiently and effectively to assess and manage their clinical settings and, ultimately, to apply these informatics skills to improve patient outcomes and the quality of patient care (**Figure 15-2**).



Figure 15-2 Data and Quality Connection: There are many ways to obtain data and information. The skill is in knowing how to access, select, and use the data

and information, applying nursing informatics to inform practice and improve patient care.

In 2016, the **Government Accountability Office (GAO)** selected and assessed six hospitals, from which it identified three challenges in implementing patient safety practices. The number one challenge was "obtaining data to identify adverse reactions in their own hospitals" (para. 2). Nursing informatics skills and knowledge can address this challenge.

The GAO interviewed patient safety experts and reviewed the related literature to identify three key gaps where better information could help guide hospital officials in their continued efforts to implement patient safety practices. These gaps involve a lack of "(1) information about the effect of contextual factors on implementation of patient safety practices, (2) sufficiently detailed information on the experience of hospitals that have previously used specific patient safety implementation strategies, and (3) valid and accurate measurement of how frequently certain adverse events occur" (p. 22). It is clear that implementing solid nursing informatics practices, skills, and knowledge can close these gaps.

Informatics Technologies for Patient Safety

Healthcare technologies are frequently designed to improve patient safety, streamline work processes, and improve the quality and outcomes of healthcare delivery. As we continue to look to health IT to advance patient safety initiatives, we must realize that integrating health IT presents other challenges and can add to patient safety issues. For example, Singh and Sittig (2015) stated that health IT has the "potential to improve patient safety but its implementation and use has led to unintended consequences and new safety concerns. A key challenge to improving safety in health IT–enabled healthcare systems is to develop valid, feasible strategies to measure safety concerns at the intersection of health IT and patient safety" (p. 226).

Although technology may certainly help to prevent or reduce errors, one must always remember that technology is not a substitution for safety vigilance by the healthcare team in a safety culture. Harrison (2016) stated that "[p]atient safety should always be at the center of the design and adoption of any technology introduced into patient care settings. Technology that's designed to improve patient safety is only as good as the person using the device. It doesn't replace critical thinking, solid nursing practice, and careful patient monitoring" (p. 21).

The Wired for Health Care Quality Act of 2005 began a series of funding streams to promote health IT and sharing of its best practices and to help organizations implement health IT (Harrison & Daly, 2009). Many early adopters opted to focus technology and safety initiatives on medication ordering and administration processes. Medication errors are the most frequent and visible errors because the medication administration cycle has many poorly designed work processes with several opportunities for human error. Thus, **computerized provider order entry (CPOE)**, automated dispensing machines, **smart pump** technologies for IV drug administration, and **barcode medication administration (BCMA)**

frequently preceded the adoption of the EHR in many institutions because of the comparatively lower costs associated with implementing these technologies. In an ideal world, the EHR would be adopted concurrently as part of an interoperable health IT system. In the early EHR systems, clinicians were prompted by electronic alerts to remind them of important interventions that should be part of the standard of care, but these alerts tended to be generalized and not patient specific—for example, "Did you check the allergy profile?" or "Has the patient received a pneumonia immunization?" These early alert and care reminders are now evolving into more sophisticated **clinical decision support (CDS)** systems to promote accurate medical diagnoses and to suggest appropriate evidence-based medical and nursing interventions based on patient data.

With the addition of triggers to detect adverse events, diagnostic errors, adverse drug events, hospital-acquired infections, and delays in diagnoses have been identified. In addition to the National Patient Safety Goals issued by the Joint Commission, which reference general safety hazards, other safety organizations and institutes provide information on top safety concerns. Cheney (2019) reported on the list of top 10 medical technology hazards of 2020 identified by the ECRI. The ECRI was founded in 1968 as the Emergency Care Research Institute and designated by HHS in 2008 as a Patient Safety Organization; in 2020, it affiliated with the Institute for Safe Medication Practices and was rebranded as ECRI, "the most trusted voice in healthcare" (ECRI, n.d.). The medical technology hazards identified by the ECRI were as follows:

1. Surgical staplers—staple line failures or misapplication
2. Point-of-care ultrasound—issues with user training, documentation and data archiving
3. Infection risks from sterile processing—especially in medical and dental offices and ambulatory settings
4. Hemodialysis risks with central venous catheters in the home health setting—risks include infection, clotting or hemorrhage

5. Surgical robotic procedures—limited tactile feedback for forces exerted on tissue may result in injury
6. Alarm, alert, and notification overload—numerous alarms may cause a clinically significant issue to be missed
7. Cybersecurity risks in the home health setting—increased vulnerabilities associated with remote monitoring and network connected medical technologies
8. Missing implant data for MRI scan patients—implants can heat, move or malfunction when exposed to MRI's magnetic field
9. Medication errors from dose timing discrepancies in electronic medical records—discrepancies between dose timing intended by the provider and nursing workflow
10. Loose nuts and bolts in medical devices—devices can tip, fall or collapse if not properly maintained (Cheney, 2019, para. 7)

Many of these issues can be prevented or detected in their early stages using informatics technologies, although we do see continued struggles with the same safety issues over several years. Other technologies designed specifically to promote patient safety include wireless technologies for patient monitoring, clinician alerts, point-of-care applications, apps, and radio-frequency identification applications. Each of these technologies is reviewed here, and the chapter concludes with a section that discusses future technologies for patient safety.

Technologies to Support the Medication Administration Cycle

The steps in the medication administration cycle (i.e., assessment of need, ordering, dispensing, distribution, administration, and evaluation) have been relatively stable for many years. Each of the steps depends on vigilant humans to ensure patient safety, which resulted in the five rights of medication administration: (1) the right patient, (2) the right time and frequency of administration, (3) the

right dose, (4) the right route, and (5) the right drug. Human error can be related to many aspects of this cycle. Distractions, unclear thinking, lack of knowledge, short staffing, and fatigue are a few of the factors that cause humans to deviate from accepted safety practices and commit medication errors. Integration of technology into the medication administration cycle promises to reduce the potential for human errors in the cycle by performing electronic checks and providing alerts to draw attention to potential errors.

CPOE is an electronic prescribing system designed to support physicians and nurse practitioners in writing complete and appropriate medication and care orders for patients. When CPOE is part of an EHR with a CDS system, the medication order is electronically checked against specific data in the patient record to prevent errors, such as ordering a drug that might interact with a drug the patient is already taking, ordering a dose that is too large for the patient's weight, or ordering a drug that is contraindicated by the patient's allergy profile or renal function. Because it is impossible for and unreasonable to expect a clinician to remember the numerous drugs that require a dose adjustment in the case of renal dysfunction, for example, safe dosing parameters are provided by the CDS associated with a CPOE (Patient Safety Network, 2019a). In a stand-alone CPOE system without a CDS system, the medication orders are simply checked by the computer against the drug database to ensure that the dose and route specified in the order are appropriate for the medication chosen. Specific benefits of a CPOE system include the following:

- Prompts that warn against the possibility of drug interaction, allergy, or overdose
- Accurate, current information that helps physicians keep up with new drugs as they are introduced into the market
- Drug-specific information that eliminates confusion among drug names that look and sound alike
- Reduced healthcare costs caused by improved efficiencies

- Improved communication among doctors, nurses, specialists, pharmacists, other clinicians, and patients
- Improved clinical decision support at the point of care (Steele & DeBrow, n.d.)

CPOE solves the safety issues associated with poor handwriting and unclear or incomplete medication orders. Orders can be entered in seconds and from remote sites, thereby eliminating the use of verbal orders, which are especially subject to interpretation errors. Orders are then transmitted electronically to the pharmacy, thus reducing the potential for transcription errors that are commonly encountered in the former paper-based system, such as lost or misplaced orders, delayed dosing, or unreadable faxes. As with any technology integration, introduction of CPOE is associated with a resistance to change in the typical workflow, a learning curve to gain proficiency, and users must learn to trust the system.

The verification and dispensing functions of the pharmacy can also be assisted by technology. The pharmacist begins by verifying the allergy status of the patient and the medication reconciliation information to ensure that the new medication is compatible with other medications in the care regimen. This verification function is computer based, and the medication order is electronically checked via the knowledge database. If the order is verified as safe and appropriate, the pharmacist proceeds to the dispensing process. Barcode medication labeling at a unit-dose level was mandated by the FDA in 2004, with targeted compliance to be achieved by 2006. A barcode is a series of alternating bars and spaces that represent a unique code that can be read by a special barcode reader. Barcode technology spans both the medication dispensing and the administration steps in the medication administration cycle. In the pharmacy, the barcode helps to ensure that the right drug and the right dose are dispensed by the pharmacy. Medications that are labeled with barcodes can also be dispensed by robots capable of reading the codes or automated dispensing machines. In this way, barcode technology helps with the processes of procurement,

inventory, storage, preparation, and dispensing (University of Rochester Medical Center, n.d.).

The processes of drug storage, dispensing, controlling, and tracking are easily carried out via automated dispensing cabinets (ADCs; also known as automated dispensing machines, unit-based cabinets, automated dispensing devices, and automated distribution cabinets). These devices have benefits for both the user and the organization, specifically in the areas of access security (especially with narcotics administration tracking), safety, supply chain, and charge functions (Institute for Safe Medication Practices, 2019). However, as Rhodes and McCarthy (2019) pointed out, errors are still possible when the override function is used to access medications from an ADC in emergent situations. They suggest that when overriding the system, the user should be forced to enter an indication for use to allow the system to detect an inappropriate medication selection from an alphabetical list. They provided two examples, one where diazepam instead of diltiazem was selected and another where vecuronium instead of Versed was selected. In the first case, if the user had been required to enter an indication, such as cardiac disturbance, they would have been prevented from selecting diazepam. Likewise, if an indication for sedation had been entered, then the ADC would have prevented dispensing a neuromuscular blocking agent.

Applications (apps), or mobile apps, are being used by and prescribed for patients. The apps used for patient education can engage and inform patients; however, apps must be used judiciously. If apps are prescribed for patients, then it is the healthcare personnel's responsibility to educate the patient and/or family on their proper use. It is important that patients and their families understand the benefits and risks of using the app as well as how to receive help when needed. If data are being exchanged, patients must comprehend what data will be collected and where, when, and with whom they will be shared. The University of Florida libraries developed this website listing patient education apps: https://guides.uflib.ufl.edu/mobilehealth/patienteducation.

There are apps for healthcare personnel as well. iScrub is an app that is used to monitor hand hygiene, which could help prevent healthcare-associated infections (Soft112, n.d.). The Patient Safety Manual for Android was designed as a resource to treat patients quickly, safely, and effectively (APKPure, 2019). Other popular apps include Pepid, Pill Identifier, Medical Spanish, Pedi STAT, Critical Care ACLS Guide, Medscape, Headspace, Pocket Lab Values, Pocket Pharmacist, and Epocrates (Morris, 2023). Apps will continue to be used by providers and patients, so all healthcare personnel must assume the responsibility of making sure that the apps are both appropriate to use and used appropriately.

Radio-frequency identification (RFID) technology is rapidly gaining a foothold in healthcare technology and may soon be used in the medication administration cycle. Although more expensive than bar coding for packaging, the RFID tags are reprogrammable, and issues associated with barcode printing imperfections and scanner resolution can be mitigated (Vecchione, 2015). As discussed later in this chapter, RFID technologies may also be an important component of a medication compliance system for patients.

BCMA systems help to ensure adherence to the five rights of medication administration. Whether BCMA is part of the larger EHR or a freestanding **electronic medication administration system (eMAR)**, barcode technology provides a system of checks and balances to ensure medication safety. The nurse begins by scanning their badge, thereby logging in as the person responsible for medication administration. Next, the barcode on the patient's identification bracelet is scanned, which prompts the electronic system to pull up the medication orders. Next, the barcode on each of the medications to be administered is scanned. This technology check ensures that the five rights of medication administration are met. If there is a discrepancy between the order and the medication that was scanned or a contraindication for administration, an alert is generated by the system. For example, in an EHR system with CDS, the nurse may be prompted to check the most recent laboratory results for electrolytes before administering a potassium supplement. In a freestanding eMAR without CDS or EHR links, if the medication

orders have recently been changed, the nurse is alerted to the change. When an alert is generated, the nurse must chart the action taken in response to that alert. For example, an early dose might need to be given if the patient is leaving the unit for a diagnostic test.

Despite the promising advances in patient safety afforded by this technology, it is not fail-safe. Medications that are labeled individually by the in-house pharmacist increase the potential for human error if the medication is given an incorrect barcode, such as one signifying a wrong dose or even the wrong medication. Many hospitals are now purchasing medications labeled by the manufacturer. Van der Veen et al. (2020) studied **workarounds** (defined as temporary practices deviating from normal workflow expectations) associated with BCMA systems. In the 5,793 medication administrations, they observed workarounds in 62.7% of the administrations. "Procedural workarounds (as not scanning at all) were most common (*n* = 1,307, 36%). Other workarounds observed were patient scanning-related (as no barcode wristband on the patient; *n* = 1,017, 28%) and medication scanning-related (including scanning before actual administration of medication, scanning medication for more than one patient at a time, and ignoring computer or scanner alerts; *n* = 400, 11%)" (p. 5). They concluded that nurse-to-patient ratios, timing of the scheduled administrations, and considerations of nurse workload were all modifiable factors that could improve compliance with this important patient safety technology. Strudwick et al. (2018) reported similar types of workarounds with BCMA that contributed to medication errors. They suggested that careful attention to nurse workflows was critical to safeguarding the proper use of BCMA.

Smart pump technologies are designed for safe administration of high-hazard drugs and reducing adverse drug events during IV medication administration. Smart pumps have software that is programmed to reflect the facility's infusion parameters and a drug library that compares normal dosing rates with those programmed into the pump. Discrepancies generate an alarm that alerts the clinician to a safety issue. A soft alarm can typically be overridden by

a clinician at the bedside, but a hard alarm requires the clinician to reprogram the pump so that the dosing falls within the facility's IV administration guidelines for the drug to be infused. All alarms generated by the smart pump are tracked along with the clinician's responses to them (Cummings & McGowan, 2011; Hulen, 2013). Smart pumps can be seamlessly integrated into BCMA systems, and data can be fed directly into the EHR. The IHI (n.d.-c) recommends the following steps to ensure safe implementation of smart pump technology:

- Prior to deploying these pumps, standardize dosing units for a given drug (for example, agreeing to always dose nitroglycerin in terms of mcg/min or mcg/kg/min but not both). Asking a nurse to choose among several dosing units increases the risk of selection error.
- Prior to deploying these pumps, standardize drug nomenclature (for example, agreeing to always use the term KCl, but not Potassium chloride, K, Pot Chloride, or others). Asking the nurse to remember and choose among several possible drug names increases the risk of selection error.
- Perform a Failure Modes and Effects Analysis (FMEA) on the deployment of these devices.
- Ensure that the concentrations, dose units, and nomenclature used in the pump are consistent with that used on the Medication Administration Record (MAR), the pharmacy computer system, and the electronic medical record.
- Meet with all relevant clinicians to come to agreement on the proper upper and lower hard and soft dose limits.
- Monitor overrides of alerts to assess if the alerts have been properly configured or if additional quality intervention is required.
- Be sure the "smart" feature is utilized in all parts of the hospital. If the pump is set up volumetrically in the operating room but

the "smart" feature is used in the ICU, an error may occur if the pump is not properly reprogrammed.

- Be sure there are upper and lower dose limits for bolus doses, when applicable.
- Engage the services of a human factors engineer to identify new opportunities for failure when the pumps are deployed.
- Identify a procedure for the staff to follow in the event a drug must be given which is either not in the library or when its concentration is not standard.
- Deploy the pump in all areas of the hospital. If a different pump is used on one floor and the patient is later transferred, this will create new opportunities for failure. Also, there may be incorrect assumptions about the technology available to a given floor or patient.
- Consider using "smart" technology for syringe pumps as well as large volume infusion devices. (para. 12)

Nurses must always engage in best practices and follow all patient safety practices. There is no substitute for nursing assessment of patients as a key safety tool.

A CDS can enhance the medication administration cycle by promoting safety and improving patient outcomes. The CDS is guided by targeted information delivery, ensuring that the five rights of CDSs are implemented: the right information provided to the right person in the right format through the right channel at the right time in the workflow. For example, during medication selection, a CDS helps a clinician select an appropriate medication based on client data, such as clinical condition, weight, renal function, concurrent medications, and cost. This system ensures that the medication order is complete by performing checks for drug interactions, duplications, or allergy contraindications and ensures that the right dose and the right route are specified. During the verification and dispensing phase of the medication administration cycle, the CDS provides double checks for interactions, allergies, and appropriate dose orders. Consideration is also given to potential infusion pump

programming issues, incompatibilities during infusion, and proper notation and dispensing when portions of a dose must be wasted. During the administration phase, the CDS assists with patient identification and current assessment parameters (i.e., blood pressure and glucose level) that may contraindicate the use of the medication at that point in time. In addition, checks for interactions with foods or other medications and timing and monitoring guidelines are provided to the clinician administering the medication. The CDS has patient education guidelines and printable handouts to assist clinicians in educating patients about their medications. The monitoring functions of the CDS provide a structured data reporting system to track side effects and adverse events across the population. Because smart pumps are often used for infusion of high-hazard drugs, systems are being developed to promote EHR bidirectional interoperability between the pump and the medical record. "With this level of bidirectional interoperability, infusion parameters are wirelessly transmitted from the EHR to prepopulate the smart infusion pump, and infusion data is also wirelessly sent back into the EHR" (Institute for Safe Medication Practices, 2017, para. 1).

Several promising technologies may become more widely available in the future to assist patients with medication compliance after discharge. For example, caps of pill bottles may contain RFID tags that monitor and collect data on when the bottle is opened or that contain flashing time reminders when a dose is due (Blankenhorn, 2010). Mason et al. (2022) point out that opening the pill bottle is a proxy for taking the medication and does not ensure adherence. Bluetooth-enabled smart inhalers track asthma medication compliance and whether the device was used properly (Amedume & Sangave, 2021). Licholai (2019) listed several technologies that use smartphones to promote adherence: Medisafe, MyMeds, Care4Today, MedMinder, and AdhereTech. InPen is a smart insulin pen that couples with a smartphone to calculate insulin dosages and track injections (Medgadget, 2016a), PillDrill helps people adhere to a medication schedule and includes a "mood cube" to track how patients are feeling (Medgadget, 2016b), and Proteus smart pills

have sensors attached to medications to track when the pill is actually ingested (Medgadget, 2015). In addition, several technologies track adherence and then issue gift card rewards (Licholai, 2019). These are just a sampling of the newer technologies for medication adherence; more are expected to emerge in the future. However, these technologies add costs to the medications that might preclude widespread adoption.

Additional Technologies for Patient Safety

CDS systems have safety uses beyond the medication administration cycle. The robust data collection and data management functions of a CDS embedded in an EHR help to ensure quality approaches to patient health challenges based on research evidence and clinical guidelines. A CDS may also ensure cost effectiveness by alerting clinicians to duplicate testing orders or suggesting the most cost-effective diagnostic test based on specific patient data (Charles, 2018).

Early uses of a CDS were limited to pop-up alerts that reminded clinicians of specific interventions, such as flu/pneumonia shots, diet counseling for those with abnormal body mass indexes, or smoking cessation interventions. Newer systems reserve alerts for critical situations, such as drug interactions/allergies and impending issues such as sepsis or cardiac failure. Limiting alerts that demanded action on the part of clinicians has helped to avoid alarm fatigue and support clinical workflow. Now CDSs are designed to provide information when requested by giving clinicians access to searchable databases and clinical guidelines. CDSs are designed to deliver the following:

- the right information (evidence-based guidance, response to clinical need)
- to the right people (entire care team—including the patient)
- through the right channels (e.g., EHR, mobile device, patient portal)

- in the right intervention formats (e.g., order sets, flow-sheets, dashboards, patient lists)
- at the right points in workflow (for decision making or action) (Bresnick, 2017, para. 20)

Stay tuned for the increased use of more sophisticated CDSs that are based on artificial intelligence and machine learning to analyze data and make predictions and care recommendations based on diagnoses and trending data (Charles, 2018).

The prompts and instructions provided to the clinician by the CDS system are detailed and designed to be easy to navigate. Implementation of a CDS has the potential to optimize care by ensuring that all the details of a patient's health issues are presented to the clinician for management, thereby promoting individualized approaches to the total health of the patient based on best available evidence and clinical guidelines (HealthIT.gov, n.d.). According to the Centers for Medicare and Medicaid Services (n.d.),

> *CDS is not simply an alert, notification, or explicit care suggestion. CDS encompasses a variety of tools including, but not limited to:*
>
> - *Computerized alerts and reminders for providers and patients*
> - *Clinical guidelines*
> - *Condition-specific order sets*
> - *Focused patient data reports and summaries*
> - *Documentation templates*
> - *Diagnostic support*
> - *Contextually relevant reference information*
>
> *These functionalities may be deployed on a variety of platforms.* (para. 2)

RFID technologies have both supply chain and patient care applications to patient safety. An RFID system contains a tag affixed to an object or a person that functions as a radio-frequency transponder and provides a unique identification code, a reader that receives and decodes the information contained on the tag, and an antenna that transmits the information between the tag and the reader. When RFID tags are embedded in patient identification

bracelets, they can help with patient tracking during procedures and testing or function as part of the EHR to communicate pertinent information to clinicians at the bedside. RFIDs may eventually be part of the medication administration process, which would replace barcode technologies. They can be used to track medical supplies and equipment, thereby reducing staff time in locating such items. They may also be embedded into surgical supplies to automate supply-counting procedures, thereby reducing the likelihood that sponges or tools will be erroneously left in a patient. RFIDs may also reduce the likelihood of the never events of wrong-patient, wrong-site surgical procedures (FDA, 2018; Patient Safety Network, 2019d; Revere et al., 2010). RFIDs used in the medication supply chain protect patients by reducing the potential that a counterfeit medication might be inadvertently introduced into the supply and providing for efficient medication recalls. Potential terrorist manipulation of the medication supply is also thwarted by RFID supply chain tracking technology. Blood and blood products can be efficiently tracked by RFIDs because specialized tags can detect temperature fluctuations and therefore ensure that the blood or blood product was stored at the optimal temperature for safe administration; however, RFID technology will probably not replace barcodes in blood banking due to the cost (Wray, 2016).

Smart rooms are also being used in healthcare facilities to better engage patients and families in the hospital experience. As a caregiver enters the room, the RFID tag on their name badge announces to the patient on a monitor (typically mounted on the wall in the patient's line of sight) exactly who has entered the room and triggers need-to-know data based on caregiver status to be displayed on the monitor in the room, thus complying with the Health Insurance Portability and Accountability Act (HIPAA). For example, when a dietary aide enters the room, only dietary information is displayed; when a physician or nurse enters, all the pertinent medical data from the EHR are available. Clinicians can review patient data in real time and chart care at the bedside using touch screen technology, thereby increasing productivity. One caution, however, is that patients have to consent to family members

and visitors to be able to view information or they will need to step out as the caregiver displays information. Some smart room technologies include workflow algorithms to alert clinicians as they enter the room about procedures that need to be implemented for the patient and can track individual clinician efficiency and effectiveness by aggregating data over time (Foley, 2017; Heath, 2020; Sharbaugh & Boroch, 2010). One of the disadvantages of smart room technology is the cost of outfitting a room with such technologies. More recently, hospitals are implementing an Internet of Things (IoT) device located at the bedside that allows the patient to use voice commands to control the room (i.e., temperature and lighting), search for health-related information, and improve communication with clinicians (Bengfort, 2017).

Smart beds, which provide continuous rotation to prevent pressure ulcers, sense when a patient at risk for a fall leaves the bed, and continuously monitor vital signs, are also being implemented (Dubinsky, 2017). Mesko (2017) described several additional innovations that may be implemented in the near future. They include robots to clean rooms efficiently and effectively, flat-screen TVs run by mobile devices for entertainment and patient education, prompts asking patients to record their pain levels on mobile devices, and the ability of clinicians to project three-dimensional images in the room to explain diagnostic findings and treatment plans.

Other technologies for improving patient monitoring include **wearable technology** and wireless area networks, variously called body area networks or patient area networks. The technologies provide the ability to wear a small, unobtrusive monitor that collects and transmits physiological data via a cell phone to a server for clinician review. Although most of these technologies are designed for monitoring patients with chronic diseases, they also have safety implications because they help to identify early warning physiological signs of impending serious health events (California Healthcare Foundation, 2013; Kosir, 2015). An early innovation was the wireless chip on a disposable Band-Aid with a 5- to 7-day battery, which was developed to monitor the patient's heart rate and electrocardiogram,

blood glucose, blood pH, and blood pressure and allowed for the collection of important clinical data outside the hospital (Miller, 2008). Wearable stress-sensing monitors detect electrical changes in the skin that may signal increased stress in autistic children who are unable to communicate an impending crisis; caregivers are alerted to the potential crisis via wireless transmission and can intervene to reduce the stress and prevent the crisis (Murph, 2019). Other new technologies promise to aid in home monitoring of an elder's movement, sleep, fall detection, health data, and/or medication data, such as Caregiver Smart Solutions, Forma SafeHome, SenSights, and Vayyar Care (Orlov, 2020). Smart fabrics with monitoring technology built in are one of the latest developments in wearable technology. Hospital gowns made with smart fabric could provide vital signs monitoring, be customized by type of patient (e.g., cardiac), or be programmed to deliver medication via the skin. Continuous monitoring via wearable technology versus intermittent vital sign checks allows for the immediate identification of decline and the need for intervention in hospitalized patients. Wearable technologies also provide important insights into health status in the community. While early technologies may have contributed to patient anxiety related to inaccurate data, the evolution of wearables promises accuracy, early detection, and timely intervention. As McGinnis and McGinnis (2022) stated, "The digital medicine revolution is at the cusp of transforming biomedical research and clinical practice by providing unprecedented access to ecologically valid health data and the ability to deliver personalized, data-informed, health-improving interventions directly to the patient wherever and whenever needed" (para. 2).

Robotics technologies are also being increasingly tested for safety and efficiency uses. Robotics has been used in minimally invasive surgery for some time; as with most technologies, there are risks and rewards (Kirkpatrick & LaGrange, 2016). Surgical robots continue to evolve, and newer technologies feature a three-dimensional high-definition vision system and precision motion controlled by the surgeon, which enables them to be used in various types of precise surgeries (Medical Education Network, 2021;

Sniderman, 2018). Robotic exoskeletons are used for gait rehabilitation after serious injuries (Sniderman, 2018). Robobear, a robot designed in Japan to assist with patient lifting, provides increased safety for both patients and clinicians (RIKEN, 2015). Laser-guided robots can move around hospitals performing such routine functions as emptying and disposing of trash, cleaning rooms, delivering supplies and meals, and dispensing drugs. Robots are now able to draw blood and collect vital signs in hospitals and are used for telehealth visits and to enhance home care; they are also created to serve as companions for the aging (typically, as cats or dogs) and for those with autism or mental health challenges. Nanorobots are being tested for use as digital pills to repair stomach issues and retrieve swallowed items (Medical Education Network, 2021). Personalized health care or precision medicine, which tailors treatment to the specific genetic characteristics of individual patients and challenges patients to be more accountable for their own health, is rapidly advancing as vendors develop targeted therapies. Its potential effect is aligned with both quality and safety. Researchers pursue specific clinical trials and make certain that the data, information, and knowledge generated are captured and disseminated. Building, analyzing, and sharing large sets of medical data allow for both innovation and targeted treatments (Medline Plus, 2022).

The International Medical Informatics Association (n.d.) Health Informatics for Patient Safety Working Group emphasized that health information systems should be designed specifically to promote and enhance patient safety and that instances of technology induced safety hazards should be widely shared to improve safety.

Role of the Nurse Informaticist

The human side of patient safety is paramount. As technologies that can help to reduce errors and increase safety are integrated into caregiving activities, healthcare professionals must also improve their ability to properly use and manage these technologies. Therefore, not only must the technology be scrutinized and tested routinely but also the users must be maintained and nurtured so that they are able to use the tools to the patient's benefit, avoiding harm and keeping the patient safe. Even the best CDS systems can contribute to mistakes by providing meaningless, outdated, or harmful information. Nurse informaticists and the IT team in the facility must ensure that all systems are properly configured and maintained. They should routinely monitor and check these systems while making sure that their users can use the systems accurately to avoid errors. A technology and its user can never be left to their own devices.

As we continue to apply informatics to patient safety, data warehousing and mining, reporting, data trending, and predictive modeling will enhance our ability to improve patient safety and provide quality health care. To gather the data and information necessary to analyze safety issues, monitoring systems, software, and hardware will continue to evolve. Risk monitoring and incident reporting software (i.e., reporting software specifically generating reports regarding incidents only), patient response monitoring systems, trending and predictive models, and reporting software will provide enhanced data and information to be analyzed.

Human inputting activities must focus on patient safety to raise the appropriate issues and sound out solutions. Nurse informaticists must be involved in all stages of the system development life cycle as new technologies are introduced while maintaining a focus on safety. Safety concerns and remedies need to be analyzed, synthesized, and integrated throughout the system development life cycle to have a robust tool that provides meaningful information and

enhances patient care while preventing errors and promoting patient safety. Nurse informaticists can bridge the gap between IT staff, electronic systems designed to ensure patient safety, and nurses who are system users by attending to the disruptions inherent in technology implementation and promoting the best and safest uses of the systems. The Research Brief describes the results of a 2020 Healthcare Information and Management Systems Society (HIMSS) survey on the effect of nurse informaticists on patient safety. This survey is conducted every 3 years, so stay tuned for the 2023 results.

RESEARCH BRIEF

In 2020, HIMSS conducted an Informatics Nurse Impact Survey building upon the research that began in 2004. This web-based survey yielded 1,359 respondents, which was an increase from 1,279 in the 2017 survey. Nursing informaticists are "the driving force behind the development, implementation, and optimization of electronic medical/health records, nursing clinical documentation, point-of-care clinical decision support, and computerized practitioner order entry" (HIMSS, 2020, para. 1).

One of the areas assessed was the chief nursing informatics officer (CNIO) role:

> *The role of CNIO/Senior Nursing Informatics Officer continues to be on the rise with 41% of respondents reporting that their organization had the formal role. In 2020, 10% of respondents reported holding the title of manager of clinical informatics as compared with just 1% in 2017. The percent of director-level respondents increased as well to 11% as compared with 7% in 2017. Still, the majority of respondents (24%) stated their title was nursing informatics specialist, a small increase over 2017's 20%. This year also showed a significant change in reporting structure, with more nurse informaticists reporting to Nursing (40%), Quality (12%), and Operations (9%) over the historical trend of reporting to IT (48%).* (HIMSS, 2020, para. 4)

This result demonstrates the belief that nurse informaticists can greatly improve patient safety. The nurse executives who responded rated the positive effect of nurse informaticists on patient safety at 6.36 out of 7.

In their conclusion, the researchers stated that

> *[t]he role of informatics nurses is not limited to IT; this research also suggests that informatics nurses play an instrumental role with regard to patient safety, change management and usability of systems as evidenced by their impact on quality outcomes, workflow, and user acceptance. These additional areas highlight the value of informatics nurses—their expertise truly translates to the adoption of more effective, higher quality clinical applications in healthcare organizations.* (p. 11)

The full article appears in: Healthcare Information and Management Systems Society. (2020). *Nursing Informatics Workforce Survey*. www.himss.org/sites/hde/files/media/file/2020/06/19/nursinginformaticsworkforcesurveyexectivesummary-final.pdf.

Interdisciplinary Collaboration

Interdisciplinary collaboration and **interprofessional collaboration** are terms used to describe cooperative relationships among actively engaged professionals where healthcare decision-making is shared to combine their collective knowledge and skills to care for their patients. All the professionals are working toward the same goal: positive patient outcomes. Interprofessional collaboration is crucial when caring for patients because the open exchange of ideas, experience, and knowledge helps the professionals develop a comprehensive plan of care.

It is important for educators and administrators to realize the potential for preparing collaborators by developing a collaborative approach and interprofessional educational activities and opportunities. Successful interprofessional collaborative education experiences will foster a willingness to participate in interprofessional collaboration efforts on behalf of patients. Refer to the website of the Centre for the Advancement of Interprofessional Education (CAIPE) for information on the principles, values, processes, and outcomes of interprofessional education: www.caipe.org/about.

Informaticists must recognize their position on the team to promote interprofessional collaboration; so, too, each professional must appreciate that they are part of an interprofessional team and are obligated to collaborate with the other team members for the patient's best interests to provide quality care to every patient. Informaticists must be willing to share, communicate, and deliberate with other professionals caring for the same patient to achieve the best outcomes for the patient. All healthcare professionals must work together to enhance quality and to secure the most positive outcomes for each and every patient treated.

The informaticist can facilitate interprofessional collaboration to improve patient care by enhancing the capability for sharing data and information in both synchronous and asynchronous formats. Therefore, the informaticist's role is critical to facilitate data,

information, and knowledge exchange in a safe and secure environment that affords professionals connectivity, access, and confidence in their ability to collaborate.

Summary

Patient safety is an important and ubiquitous issue in health care. This chapter explored the characteristics of a safety culture and technologies designed to promote patient safety. The need to evaluate errors carefully to determine why and how they occurred and how workflow processes might be changed to prevent future errors of the same type was emphasized. Technology is changing rapidly, and the culture of sharing related to technology implementation, error reporting, and troubleshooting should prompt continuous process improvements. The key for organizations is to invest in their users and to choose wisely so that the technologies they are adopting will not negatively affect safety and will be interoperable and easily upgradable as technologies and safety practices evolve.

Organizations must make a commitment to a safety culture in which everyone at every level is committed to patient safety at every moment. In an ideal world, everyone would first stop and think "Is this safe?" before every action, workarounds would not occur, and everyone would embrace the technologies and workflow processes designed to promote patient safety. **Table 15-1** provides a list of websites to consult for updates on patient safety technologies. The nurse informaticists, healthcare providers, patients, ancillary team members, administrators, settings/environments, infrastructures, and technologies must all work together to create a safety culture. Every organization must provide safe, quality health care and prevent harm or **adverse events** for every patient under its care by ensuring that patient safety is critical to the organization's mission.

TABLE 15-1 Patient Safety Websites

Title	URL
AHRQ Patient Safety Network	https://psnet.ahrq.gov
VHA National Center for Patient Safety	www.patientsafety.va.gov
Institute for Healthcare Improvement	www.ihi.org/topics/patientsafety/Pages/default.aspx
Center for Patient Safety	www.centerforpatientsafety.org
QSEN (Quality and Safety Education for Nurses) Institute	https://qsen.org

THOUGHT-PROVOKING QUESTIONS

1. What are the current patient safety characteristics of your organizational culture? Identify at least three aspects of your culture that need to be changed regarding patient safety and suggest strategies for change.
2. Describe a current technology that you use in patient care that would benefit from human factors engineering concepts. What are some ways this technology should be improved?
3. Identify a workaround that you have used and analyze why you chose this risk-taking behavior over a behavior that conforms to a safety culture.
4. The GAO (2016) interviewed patient safety experts and reviewed the related literature to identify three key gaps in patient safety practice implementation:

   > *a lack of (1) information about the effect of contextual factors on implementation of patient safety practices, (2) sufficiently detailed information on the experience of hospitals that have previously used specific patient safety implementation strategies, and (3) valid and accurate measurement of how frequently certain adverse events occur.* (p. 22)

Select one of these gaps and describe in detail how nursing informatics could help close it.

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CHAPTER 16

Patient Engagement and Connected Health

OBJECTIVES

1. Define health literacy and eHealth.
2. Explore various technology-based approaches to consumer health education.
3. Assess barriers to the use of technology and the issues associated with health-related consumer information.
4. Imagine future approaches to technology-supported consumer health information.

KEY TERMS

- artificial intelligence (AI)
- blog
- connected health
- digital divide
- domain name
- eHealth
- eHealth Initiative
- empowerment
- gray gap
- health literacy
- HONcode
- interactive technology

- mobile app
- patient engagement
- static medium
- TRUSTe
- voice recognition
- web quest
- weblog

Introduction

Imagine that you have decided to take up running as your preferred form of exercise in a quest to get in shape. You start slowly by running a half mile and walking a half mile. You gradually build up your endurance and find yourself running nearly every day for longer distances and longer periods of time. But then you notice a nagging pain in your right hip; over a few weeks, it gradually spreads to the center of your right buttock and then down your right leg. You try rest and heat, but nothing seems to help. You visit your doctor, who indicates that you have developed piriformis syndrome and prescribes a series of stretching exercises, ice to the involved area, and rest. You are intrigued by the diagnosis. Upon your return home, you log on to the internet and begin a search for information about piriformis syndrome. When you type the words into your favorite search engine, you immediately get 2,780,000 results in response to your query.

Your use of the internet to seek health information mirrors the behavior of many consumers who are increasingly relying on the internet for health-related information. The challenge for consumers and healthcare professionals alike is the proliferation of information on the internet and the need to learn how to recognize when information is accurate and meaningful to the situation at hand.

This chapter explores consumer information and education needs and considers how **patient engagement** and **connected health** technologies, including new trends in wearable technology, may help to meet those needs yet at the same time create ever-increasing demands for health-related information. It begins with a discussion of health literacy, **eHealth**, and health education and information needs and explores various approaches by healthcare providers to using technology to promote health literacy. Also examined is the use of games, **web quests**, and simulations as a means of increasing health literacy among the school-age population. Issues associated with the credibility of web-based information and barriers

to access and uses for patient engagement are discussed. Finally, future trends related to technology-supported consumer information and connectivity are explored.

Consumer Demand for Information

This is the Knowledge Age; most people want to be in the know. People demand news and information and want immediate results and unlimited access. The same is increasingly true with health information. More and more people, in a trend known as consumer empowerment, patient engagement, and connected health, are interested in partnering with healthcare providers to take control of their health. These patients are not satisfied with being dependent on a healthcare provider to supply them with the information they need to manage their health. Instead, they are increasingly embracing electronic technologies, such as patient portals, to offer current and past health statuses, lab results, and secure messaging with providers; social media interactions; health-related games; wearable technologies for tracking health; and health management apps. Refer to **Box 16-1** to review three apps and reflect on how nurses can engage with and connect their patients to their own health, whether it be diet and exercise help; medication support; or something specific to their contextual situation, such as pregnancy or monitoring their heart's function.

BOX 16-1 MOBILE APPS: APPLICATIONS TO CONNECT AND ENGAGE PATIENTS

Mobile apps are software programs that operate on smartphones and other mobile communication devices. They can also be accessories that connect to a smartphone or other mobile communication device. Given these definitions, they can be a combination of accessories and software. There are mobile apps for health and medicine that patients use to manage their own health and wellness. According to Edwards, in 2019, there were over 97,000 health and fitness apps on the market, 15% of 18- to 29-year-olds have installed health-related apps on their smartphones, 8% of 30- to 49-year-olds have installed medical apps, 40% of physicians said these tools can decrease the number of face-to-face clinical visits, and 93% of physicians believed that mobile apps

can improve the quality of patient health. The fitness app market grew 45% in 2020, and unique users reached 385 million in 2021 likely as a result of the pandemic (Curry, 2023). Mobile apps have a place in the delivery of health care because they help to engage patients with their own health, wellness, and overall health status. These apps not only engage but can also empower patients to actively contribute to and participate in their health care.

THE BUMP

The Bump (www.thebump.com) provides pregnancy and parenting information. It reviews planning a family, each trimester of pregnancy, and parenting.

MEDISAFE

Medisafe (www.medisafeapp.com) is a personalized medication reminder app for each medication a person is taking and also provides drug interaction warnings. You can list caregivers as Medfriends, and the app will send them notifications if you miss a medication. Easily share the medications you are taking with your healthcare provider because they reside on your smart device.

KARDIAMOBILE

KardiaMobile (www.alivecor.com/kardiamobile) is an app with a battery-operated device that has two pads; lightly place your index and middle fingers from one hand on one pad and your index and middle fingers from the other hand on the other pad. This device is 3.20 inches (8.2 cm) by 1.25 inches (3.2 cm) by 0.14 inches (0.35 cm) with two 1.18-inch (3 cm) by 1.18-inch (3 cm) stainless steel electrodes. To use this device, you must place it near your smartphone, open the app on your smartphone, and choose record. Your EKG is visible on your smartphone and is recorded and saved to be shared with healthcare providers. You will see your results after a 30-second recording and receive a personalized heart health report every 30 days with a summary of your EKG and blood pressure readings to share with your healthcare provider. This mobile app is an example of a combination of accessories and software.

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A national survey by the Pew Research Center's Internet and American Life Project (Fox & Duggan, 2013) indicated that 8 in 10 Americans who are online have searched for health information (these numbers are comparable to the numbers in previous surveys conducted in 2006 and 2011). The most frequent health topic searches (69%) were related to a specific disease or medical problem that the searcher or a member of the family was experiencing. Other frequent topics of health-related searches were weight, diet, and exercise (60%) and health indicators, such as blood parameters or sleep patterns (33%). The 2011 survey (n = 3,001) indicated that consumers also searched for information on food (29%) and drug safety (24%; Fox, 2011). Just over half of "online diagnosers" (i.e., those who search online for information about medical conditions) reported that they shared their internet findings with their healthcare providers, and 41% reported that their findings were confirmed by a clinician (Fox & Duggan, 2013). It is clear that patients are increasingly looking to be partners with their healthcare providers in managing their health challenges and maintaining a level of wellness. Stansberry et al. (2019) studied 530 participants. The majority of their comments surrounded their hopes and concerns over technological changes occurring in their lives; they referred to technological advances such as "brain-computer interfaces, virtual immersive experiences that will teach and entertain users, pervasive connectivity linked to **artificial intelligence (AI)** that helps people navigate the world and understand it better, and predictive and personalized applications that make life easier" (para. 1). Carmona et al. (2022) collected data on 2,437 users of a web-based symptom checker using AI—Buoy Health. They reported that over half of the users had pain, a lump or mass, or a gynecological issue, and many were directed to seek care within a week or to self-care. "The results of this study demonstrate the potential utility of a web-based health information tool to

empower people to seek appropriate care and reduce health-related anxiety" (p. 15). **Box 16-2** provides an overview of AI as a patient engagement strategy.

BOX 16-2 ARTIFICIAL INTELLIGENCE (AI) APPLIED AS A PATIENT ENGAGEMENT STRATEGY

In today's competitive and confusing healthcare delivery system, it is important that providers be able to personalize each patient's experience. Open communication is key to remaining current with the needs of patients while making them feel connected to the practice and satisfied with the care they receive. In a blog post on Seismic (2017), it was stated that "[w]hen it comes to patient engagement, the promise of AI is to improve the experience by anticipating patient needs, providing faster and more effective outcomes" (para. 7). Seismic recommended the following:

- Engaging patients with insights that are conversational and contextual, and adjusting based on the situation to respond in real time.
- Teaming providers with the intelligent guidance of AI so they can provide patients with next-best actions, personalized to them.
- Empowering patients who want to actively participate and engage in their health with intelligent guidance and support when needed. (para. 7)

The blog post stated it best:

> *A smart machine might be able to diagnose an illness and even recommend treatment better than a doctor; however, it takes a person to sit with a patient, understand their life situation, and help determine which treatment plan is optimal. (para. 9)*

Heath (2019) stated that a "survey of 2,000 healthcare consumers and 200 business decision makers (BDMs) revealed that AI may soon be the future of patient care" (para. 2). AI must not only engage patients but also engage healthcare providers and facilitate their ability to provide healthcare. Marr (2018) stated that AI can help with critical thinking, clinical judgment, image analysis, robotic-assisted surgery, and diagnosing. He also described providing virtual nursing assistants to monitor patients and facilitate communication and information exchange between face-to-face visits. Heath (2018) discussed the high patient satisfaction scores when patients are provided virtual care: "[F]orty-seven percent of patients said they prefer a more immediate, virtual

care encounter than having to wait for an encounter that is in person" (para. 7). AI in the form of virtual nursing assistants can help patients feel connected and engaged in their care.

Reflect on the following AI virtual patient encounter; assume each role (nurse, Craig, and patient, Mary), and assess your perspective as each one. The AI virtual nurse is known as Kate.

AI VIRTUAL PATIENT ENCOUNTER SCENARIO

Mary has an appointment at the nurse-managed clinic next week but has questions about how she is feeling now. Mary grabs her tablet; opens the virtual AI app; and reaches out to Kate, her virtual nurse.

Kate is an intelligent virtual nurse who appears as an avatar. She is powered by AI and is continuously learning about her assigned patients from both the patients and the nurses with whom she interacts frequently. Kate receives Mary's call and immediately reviews her information:

> *Mary has been in what she classifies as "great health" all her life until now, "hitting 45 did me in." She is a 45-year-old woman who has never married and was steeped in her career as an architect, for which she traveled 3 weeks out of every month. She had a myocardial infarction last month and has since been afraid to assume her activities of daily living and is terrified of going back to work. She reaches out at least once per day and submits monitoring data every 3 to 4 hours, at least 5 times per day. Her EKG monitoring device works through her smartphone and records her EKG, blood pressure, pulse, and respirations.*
>
> *Kate has been monitoring Mary's submissions and notices that she is tachycardic generally once per day in the evening but not the other four times she submits her EKGs and vital signs. Kate had a discussion with Mary's nurse, Craig, last week. Craig had a cardiologist review the EKGs to make sure everything was fine. The cardiologist did not find an issue with the EKG but wanted to know more about the tachycardia since it occurs only once daily. Craig shared the results from the cardiologist's assessment with Kate. Craig also asked Kate to correlate Mary's activities so that they could determine what is occurring in the evening when she becomes tachycardic since all the other vital sign submissions are within normal limits. Kate reported to Craig that the tachycardic episodes correlate to when Mary's mom leaves to go home for the night.*

Kate responds in fewer than 15 seconds to Mary's call and says, "Hello, Mary. What can I do for you?"

Mary says she will submit her monitoring information since she feels like her heart is beating fast this afternoon.

Kate tells Mary that she has received the data and to please wait a moment while she reviews it. It is immediately evident that Mary is tachycardic. Kate asks Mary all the appropriate questions related to assessing whether the tachycardia is of concern. She determines that it is not of concern at this time.

Mary states that she is not feeling dizzy but that she feels her heart race at least once a day: "It scares me!"

Kate asks whether her mom is still there since it is early afternoon.

Mary states that her mother just left.

Kate remembers that Craig wanted her to ask Mary more detailed questions surrounding when her mother leaves. Kate begins questioning Mary about what she has been doing for the past hour and exactly when her mother left.

Mary tells Kate that the only thing she's done is drink the big cup of hot chocolate that her mom had made her before she left and that she had to leave early today. "She takes such good care of me and always leaves me with a magazine and a cup of hot chocolate."

Kate asks her to resend a set of vital signs, including EKG, in two hours. Kate also asks Mary whether she has any other questions or needs anything else at this time.

Mary says that she is fine and will send in her information in 2 hours.

Kate reaches out to Craig and informs him of the hot chocolate Mary's mom makes when she is getting ready to leave her. Craig thanks Kate for the information and asks her to continue to monitor Mary's EKG and vital signs.

Mary complies and submits her requested data to Kate.

Kate reviews the information Mary has sent and determines that everything is normal. She calls to let Craig know.

Craig reaches out to Mary to assess her caffeine intake throughout the day and to verify that she feels OK since her vital signs and EKG indicate that she is doing well.

Mary states that she does not knowingly have any other caffeinated foods or drinks throughout the day. She says her "mother is going to be very upset since she is the one causing me to race."

Craig answers all Mary's questions and assures her that Kate will continue to monitor her and is readily accessible if she needs anything when Craig is not available.

Craig then calls Kate and has a discussion with her about asking dietary questions and following up on what is occurring in the patient's situational context around variations noticed in EKGs and vital signs with their cardiac patients.

Kate is still learning, and the time Craig spends with her helps to hone her skills and ability to assess and help their patients.

It is important to note that Kate's developer, a nurse informaticist, required social context and patient feelings/insights as required information for the AI

virtual nurse to receive and assess in addition to the healthcare data and information related to the patient's health, illness, or care needs.

As the patient, would you want to interact with Kate? Describe your answer.

As the nurse, answer the following questions:

- Would you trust Kate to interact with your patients?
- How much time would you be willing to spend to help Kate learn?
- How would you assess Kate's performance and growth over time?
- Would you be interested in working with the AI developers to better understand her capabilities, make suggestions, and further enhance Kate's abilities?

Where do you believe AI capabilities will be in 5 years? How about in 10 years?

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All healthcare professionals must be prepared to listen to their patients' ideas about their personal health and at the same time provide direction toward credible health information supplied by electronic provider portals on the internet. Here is some good news: In an attempt to improve the credibility of the results of online searches about health, in 2015 Google partnered with the Mayo Clinic to fact check the information in a database for 400 of the most commonly searched for health issues (Lapowsky, 2015). According to

Dr. Pearl (2019), algorithms must be altered to help differentiate good sources from those providing misinformation, credible sources should accept direction and assistance from the healthcare community, and warnings should be added to websites that are sharing unsafe or dangerous health information. Healthcare is different from other industries. Dr. Pearl makes a distinction about the ability of consumers reading sales ads or information from other sites: "When most shoppers come across a Rolex watch selling for $19.99 online, they know it's a scam. But when it comes to medical information, many patients and parents don't have the scientific expertise to discern what's real from fake" (para. 13). Medical misinformation exploded on the internet during the COVID-19 pandemic. Shajahan and Pasquetto (2022) stated, "Countering misinformation requires addressing long-standing challenges that operate within social, psychological, economic, technological, and political dynamics" (p. 124). They were part of a team that developed a misinformation toolkit for providers, MisinfoRx. They suggest that when patients present inaccurate information that they found on the internet that providers acknowledge the health information–seeking behavior and then gently correct misinformation. They also caution about commenting or arguing on misinformation posts on the internet, as this boosts the post. Rather, if providers have an online presence, they should seek to post accurate information and to like or share the accurate posts of others.

It is important to note that surveys of online health behaviors are limited to those individuals who are online; therefore, they do not reflect the health information needs or demands of those persons who are not online. **Digital divide** is the term used to describe the gap between those who have and those who do not have access to online information. Nurses and healthcare providers must be aware of the various components of the digital divide to ensure that patients and clients are receiving the health information they need in a format that they are interested in and can comprehend. Notably, persons with chronic diseases are less likely to have internet connectivity. Fox and Purcell (2010) explained that having a chronic

disease is associated with age, level of education, ethnicity, and income—all factors that are also associated with the digital divide. Persons living with a chronic disease who have internet access are likely to use the internet for blogging and online discussion forums, activities popularly referred to as peer-to-peer support. An issue brief by the Council of Economic Advisers (2015) reiterated digital divide factors as age, education, income, and geographic location. In 2021, the National Telecommunications and Information Administration released a countrywide interactive map of the digital divide (www.ntia.gov/press-release/2021/ntia-creates-first-interactive-map-help-public-see-digital-divide-across-country). By providing infrastructure investment monies, the ConnectED initiative was designed to increase broadband access for schools. A similar initiative is designed to promote competition among internet providers, thereby lowering costs and making high-speed internet connections more affordable and accessible across the country. One of *Healthy People 2030*'s overarching goals remains "Eliminate health disparities, achieve health equity, and attain health literacy to improve the health and well-being of all" (HealthyPeople.gov, n.d., para. 1). Thobias and Kiwanuka (2018) stated that there are challenges and barriers to information dissemination in low-resource settings in their study. One area was the lack of access to phones for mothers. They presented a data model that would leverage the leaders in the community who owned smartphones and others, including relatives, to assist with transmitting health education messages to the mothers. Their study has shown the feasibility of using phones to communicate with mothers who do not actually own phones. This is a great example of providing technologies that work with the constraints of the situation. Another example of addressing the digital divide is the growing number of health-related websites that support Spanish and other language formats.

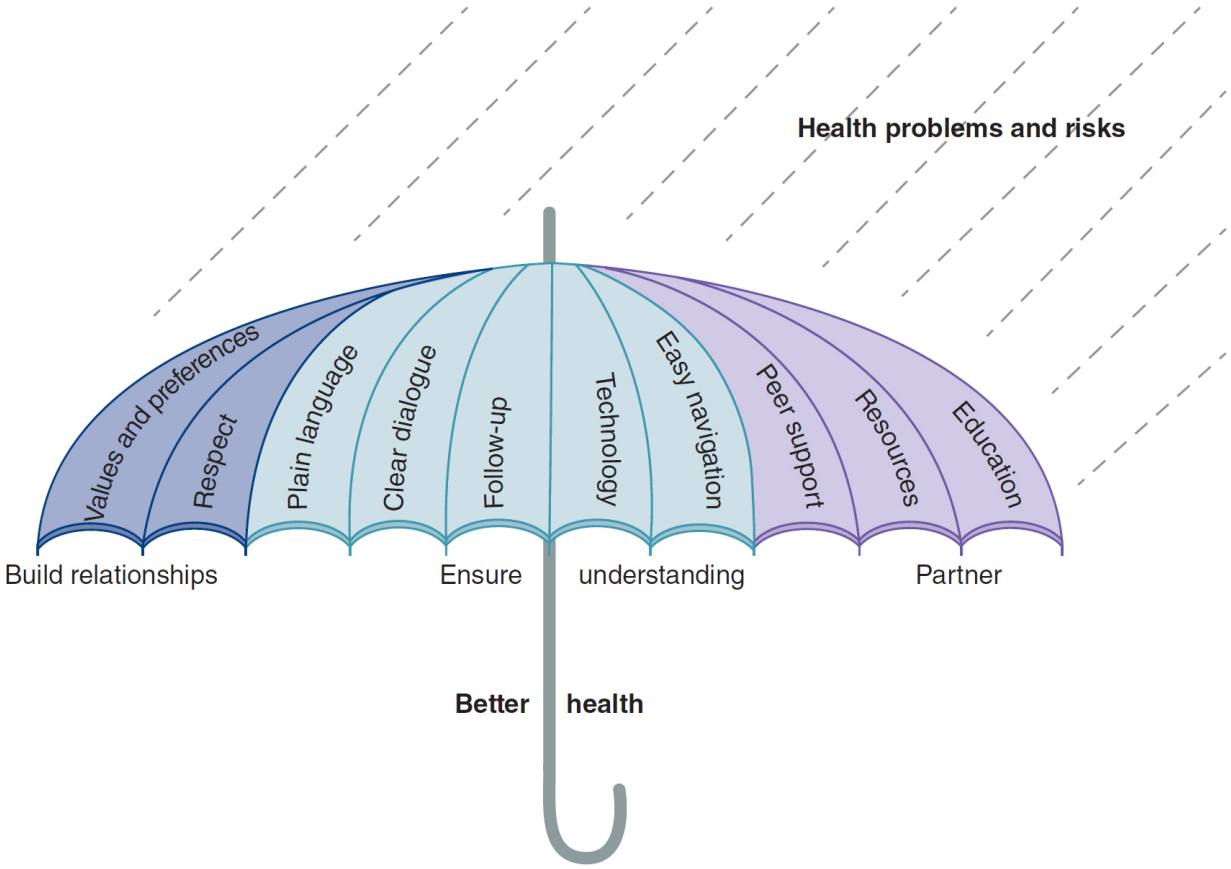
Health Literacy and Health Initiatives

The goal of **health literacy** for all is one that is widely embraced in many sectors of health care and remains an overarching goal for *Healthy People 2030* (Health.gov, n.d.). Clinicians who have been practicing for some time recognize that informed patients have better outcomes and pay more attention to their overall health and changes in their health than those who are poorly informed. Some of the earliest formally developed patient education programs, which included postoperative teaching, diabetes education, cardiac rehabilitation, and diet education, were implemented in response to research that suggested the positive effect of patient education on health outcomes and satisfaction with care.

The Health Resources and Services Administration (2022) concluded that those persons with low health literacy have difficulty understanding what healthcare providers are telling them, lower educational skills, cultural barriers to health care, and issues managing chronic illnesses. Low health literacy affects the incidence and management of disease. "Health literacy is the degree to which individuals have the ability to find, understand, and use information and services to inform health-related decisions and actions for themselves and others" (para. 1). For example, healthcare providers depend on a patient's ability to understand and follow directions associated with dietary restrictions or exercising at home. It is also assumed, sometimes erroneously, that people will correctly interpret symptoms of a serious illness and act appropriately. Locating and evaluating health information for credibility and quality, analyzing the various risks and benefits of treatments, and calculating dosages and interpreting test results are among the tasks that are essential for health literacy. Other important and less easily learned health literacy skills are the ability to negotiate complex healthcare environments and understand the economics of payment for services.

The National Institutes of Health (NIH; 2021) reported that numerous studies concerning health literacy demonstrate that a variety of challenges remain on both the patient and the healthcare provider sides of the equation. This is still true today, as evidenced in the *Healthy People 2030* overarching goals. Health.gov (2016) created a health literacy online guide that was last updated in 2016 but that still contains valuable information, such as the Health Literacy Online Strategies Checklist. According to Health.gov (2021), "Health literacy and clear communication between health professionals and patients are key to improving health and the quality of health care" (para. 1).

It is increasingly clear that better outcomes result when patients are well informed and engaged in their care. As depicted in **Figure 16-1**, there are a number of effective strategies to promote better health, including strategies for building sound relationships, strategies to ensure that patients are well informed about their health challenges, and strategies to build partnerships with patients.



Developed by the Health Literacy in Communities Prototype Faculty: Connie Davis, Kelly McQuillen, Irv Rootman, Leona Gadsby, Lori Walker, Marina Niks, Cheryl Rivard, Shirley Sze, and Angela Hovis with Joanne Protheroe and the Ministry of Health, July 2009. IMPACT BC, with funding from the BC Ministry of Health.

Figure 16-1 The Health Literacy Umbrella

Description

The **eHealth Initiative** was developed to address the growing need for managing health information and promoting technology as a means of improving health information exchange, health literacy, and healthcare delivery. Visit the eHealth Initiative website (www.ehidc.org) for information. Although its scope goes beyond health literacy, a major goal continues to be empowering consumers to understand their health needs better and to act appropriately to those needs. The eHealth Initiative recently released a 2020 road

map outlining a vision toward patient-centric care. Poor interoperability among healthcare systems and failure to embrace national data standards for health care continue to be identified as barriers to the eHealth Initiative. Further, concerns about privacy and security of information and the failure to invest appropriately in technology have slowed the development of this important initiative. The Centers for Disease Control and Prevention (CDC; 2023b) provides access to health literacy and eHealth initiatives by state (www.cdc.gov/healthliteracy/statedata/index.html).

Healthcare Organization Approaches to Engagement

Healthcare organizations (HCOs) use a wide variety of approaches and tools to engage patients and promote patient education and health literacy. Although the old standby for disseminating information is the paper-based flyer, some HCOs are recognizing that today's consumers are more attracted to a dynamic medium rather than to a **static medium**. In addition, the cost of designing and printing pamphlets and flyers becomes prohibitive when one considers the rapidity of changing information; the brochure may be outdated almost as soon as it is printed. One approach to deal with these issues is to have patient education information stored electronically so that changes can be made as needed or information can be better tailored to the specific patient situation and then printed out and reviewed with the patient.

Another old standby approach that is still widely used is the group education class. These classes initially were developed to help people manage chronic health problems (e.g., diabetes) and were typically scheduled while people were hospitalized. Now many HCOs also sponsor health promotion education classes as a way of marketing their facilities and showcasing their expert practitioners.

The movement from static to dynamic presentations began in many HCOs with the use of videotapes and then DVDs, which were shown in groups or broadcast on demand over dedicated channels via a television in patients' rooms. HCOs are now also taking advantage of the fact that patients and families are captive audiences in waiting rooms by promoting education via pamphlet distribution, health promotion programs broadcast on television, and health information kiosks in those locations. The kiosks are typically computer stations and often contain a variety of self-assessment tools (especially those related to risks for diabetes, heart disease, or cancer) and searchable pages of information about specific health

conditions. The self-assessment tools represent yet another step forward in technological support for education; in addition to being dynamic, the kiosk is interactive. On the assessment page, the user is asked to respond to a series of questions and then the health risk is calculated by the computer program. One caution, however, is that just because the information is made available does not mean that people will participate or understand what they have experienced. Issues related to the level of health literacy, the digital divide, and the **gray gap** (i.e., differences in electronic connectivity by age) still exist in these situations.

Many HCOs have invested time and money in developing interactive websites and believe that web presence is a critical marketing strategy. Consider how the information in **Box 16-3** might be attractive to a consumer. Most websites offer physician search capabilities, e-newsletters, and call-center tie-ins. As with all patient education materials, there must be a sincere commitment to keeping information current and easily accessible. Web designers must pay particular attention to the aesthetics of the site, the ease of use, and the literacy level of those in the intended audience.

BOX 16-3 THE SCIENCE FICTION–REALITY FACTOR

It is true that we want to have a health-literate and truly engaged patient to partner with their healthcare journey. It is a stretch at times for patients to comply with or understand their treatment plan and/or medication regimen. Inc. (2018) brought a new level to literacy and engaging patients and their significant others or caregivers. It provided the following example of sci-fi meeting reality when it stated that "3D printing is a cutting-edge innovation in health care today" (para. 5). It can be used to generate casts, and "some scientists are now experimenting with 3D-printing organs" (para. 5).

APPLICATION

What if a "child needs a prosthetic hand—printing it at home could drastically lower the cost" (Inc., 2018, para. 6) as well as decrease the time to receive the replacement.

Reflect on how health literate and engaged the parents and/or caregiver must be to accomplish this task.

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The aim of the review conducted by Reen et al. (2019) was "to synthesize the usability of specific health information websites" (para. 2). They provided insights into how to assess website usability. It is important to collect information on user site preferences and user satisfaction with websites. "Preferred website features were interactive content such as games and quizzes, as well as videos, images, audio clips, and animations" (para. 4). When considering the adolescent population, it was important for them to be able to communicate or interact with other like adolescents, and they wanted to learn about their situation by hearing true stories in other adolescents' own words.

The rapid growth of electronic communication through increased use of computers and access to the internet, particularly for medical purposes, empowers the clinician as well as the consumer of healthcare information. The integration of information and communication technologies and the growing trend of consumer empowerment have reshaped the delivery of health care. As a result of meaningful use initiatives, many HCOs have developed secure patient portals that allow patients to access their health records, including tracking laboratory results and reviewing the records. Most HCOs, however, do not allow patients to edit these records. In addition, patients are occasionally interested in interacting with others who have the same or similar conditions, and some HCOs are providing the information necessary to help them connect. This peer-to-peer support is especially popular with patients who have cancer diagnoses, diabetes, and other chronic and debilitating conditions (Lober & Flowers, 2011).

Some HCOs are using social media for health education to promote actual engagement of audiences rather than as a means of one-way messaging. Neiger et al. (2013) suggested "that the use of social media in health promotion must lead to engagement between the health promotion organization and its audience members, that engagement must provide mutual benefit, and that an engagement hierarchy culminates in program involvement with audience members in the form of partnership or participation (as recipients of program services)" (p. 158). The CDC (2011) has an excellent social media tool kit that can be used by health educators to guide the planning and implementation of social media strategies for health promotion: www.cdc.gov/healthcommunication/ToolsTemplates/SocialMediaToolkit_BM.pdf. The CDC (2023a) also has a social media overview page at www.cdc.gov/healthcommunication/toolstemplates/socialmediatoolkit_bm.pdf. The CDC (2023a) also has a digital and social media page at www.cdc.gov/digital-social-media-tools/index.html.

Promoting Health Literacy in School-Age Children

Promoting health literacy in school-age children presents special challenges to health educators. There is wide agreement that childhood obesity is a serious and growing issue, which is related not only to poor choice of foods but also to the sedentary lifestyles promoted by video games and television. In addition, the time once devoted to health and physical education programs in schools has given way to more time spent on core subjects, such as math and science. Auld et al. (2020) recommended strategies to support health-enriching behaviors, such as customizing and personalizing information and engaging students using age and developmentally suitable information, materials, teaching techniques, and learning approaches. The eHealth programs are developed specifically to appeal to the generational (i.e., highly connected and computer literate) and cultural needs of this group.

Although sedentary lifestyles promoted by video game engagement may contribute to obesity, gaming may be an effective way to promote health literacy. Here are a few examples and an overview of very early games. As early as 2005, Donovan described an interdisciplinary web quest designed to appeal to older school-age children. The quest is interdisciplinary in that it requires reading comprehension, critical thinking, presentation, and writing; thus, core skills and health literacy skills are learned in a single assignment. Students are directed to the web to search for information on the pros and cons of low-carbohydrate diets and obesity prevention. Students learn along the way as they search for information, collect and interpret it, and then develop a presentation and final paper.

The Cancer Game (Oda & Kristula, n.d.) was developed by a young man taking a college class on Macromedia software who had previously undergone a bone marrow transplant. Subsequently, he

and a professor collaborated and expanded the project to its present form. The game is designed as an arcade-style video game for cancer patients to relieve stress by visualizing the fighting of cancer cells. Although cancer victims of any age can access and play the game, it has a special appeal to children and adolescents. Similarly, *Ben's Game* (https://archive.org/details/bensgame) is a video game designed to help relieve the stress of cancer treatment for children (Anderson & Klemm, 2008). According to Cullen et al. (2016), *Squires Quest II* is a serious video game designed to increase fruit and vegetable consumption in fourth and fifth graders; these authors found an increase in fruit intake at breakfast and increased vegetable intake at dinner. This is a great example of a health education program designed to appeal to this connected generation of learners and their intuitive ability to use **interactive technologies**.

You can access newer games on the internet by typing "health games" into a search engine. Be sure to review the information presented in the game for accuracy before you recommend it to parents and children. The National Library of Medicine maintains a site dedicated to health learning games for both children and adults (https://medlineplus.gov/games.html). You can feel confident in recommending games from this trusted website because it has been vetted for accuracy and credibility.

Winkelman et al. (2016) reported that only 12% of adults in the United States are proficient in health literacy, or the ability to successfully navigate and function in the healthcare system. This is cause for grave concern because health literacy is one of the strongest predictors of health; it is more prognostic than gender, age, income, or educational status (Leiditch, 2021). Low health literacy is linked with poor child health outcomes, increased healthcare costs, and higher mortality rates (Schools for Health in Europe, n.d.; Winkelman et al., 2016). It is easy to understand why the CDC (2022) has a website on health literacy to support schools (www.cdc.gov/healthliteracy/education-support/schools.html) and why health literacy was included in *Healthy People 2010* and *Healthy People 2020* and continues as a goal in *Healthy People 2030*.

Supporting Use of the Internet for Health Education

Nurses and other healthcare providers must embrace the internet as a source of health information for patient education and health literacy. Patients are increasingly turning there for instant information about their health maladies. Health-related **blogs** (short for **weblogs**, or online journals) and electronic patient and parent support groups are also proliferating at an astounding rate. Clinicians need to be prepared to arm patients with the skills required to identify credible websites. They also need to participate in the development of well-designed, easy-to-use health education tools. Finally, they need to convince payers of the necessity of health education and the powerful effect education has on promoting and maintaining health. **Box 16-4** provides more information about patient education.

BOX 16-4 CONSIDERATIONS FOR PATIENT EDUCATION

Julie A. Kenney and Ida Androwich

Nurses need to consider many things when teaching patients. They need to assess patients' willingness to learn and reading ability, the means by which they learn best, and their existing knowledge about the subject. These important considerations for patient education are depicted in **Figure 16-2**.

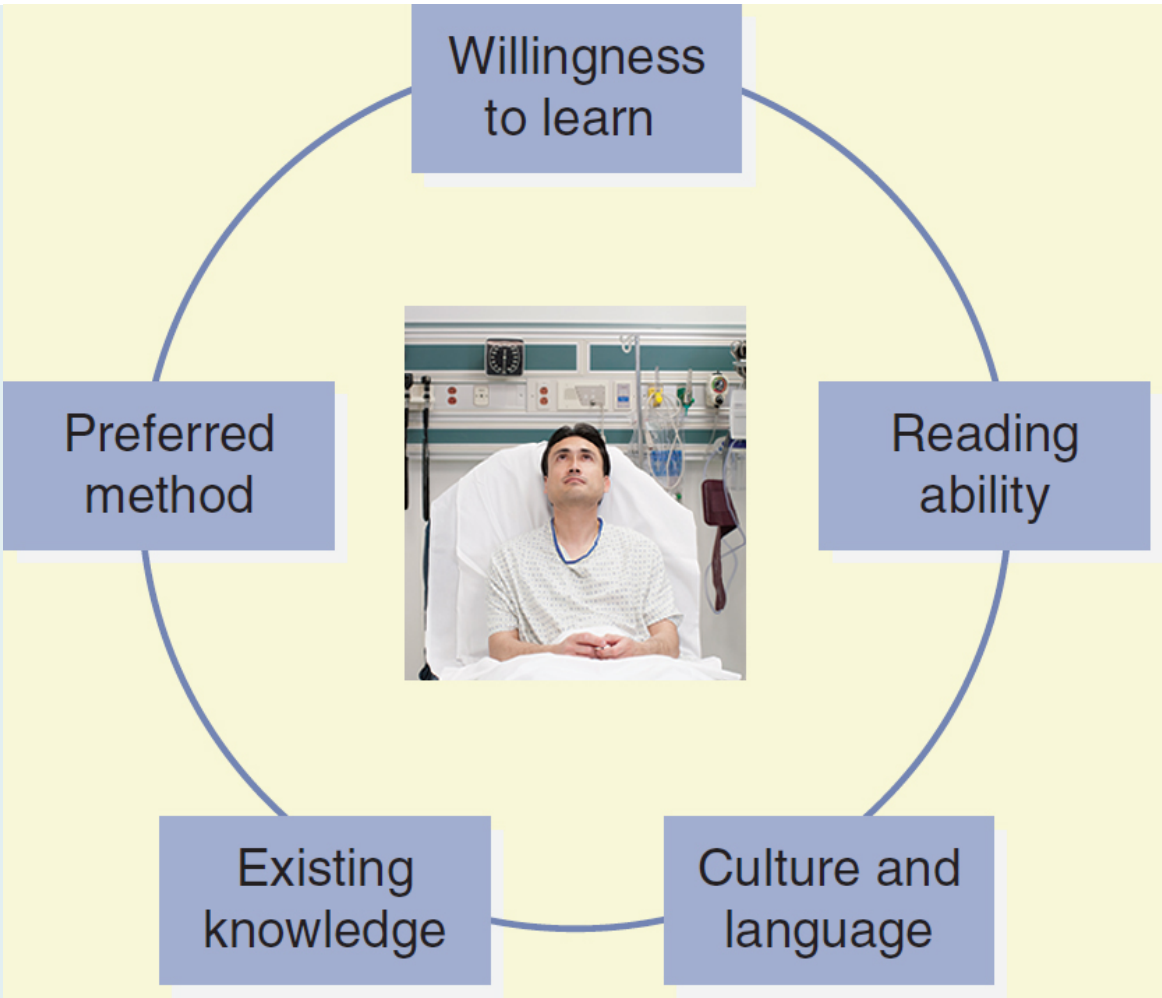


Photo: © ERproductions Ltd/Blend Images/Getty Images

Figure 16-2 Choosing an Education Strategy

Nurses also need to consider cultural, language, and generational differences when teaching their patients. If the nurse chooses to use an electronic method to educate the patient, digital natives (i.e., patients who have grown up with technology) need to be taught differently from digital immigrants (i.e., those who are late adopters of technology; "Educational Strategies," 2006). Digital natives are typically born after 1982 and may also be referred to as Millennials. This generation prefers to learn using technology and learns quite well if information is presented in a format to which they are accustomed, such as an interactive video game to introduce them to a topic. This group is also comfortable using information that they can access via their handheld devices, such as smartphones and tablets, as well as wearable devices, such as smartwatches. Those born before 1982 have learning styles that range from preferring to learn in a classroom setting to reading a book

about the topic to learning using a hands-on, interactive approach ("Educational Strategies," 2006).

A systematic review of the literature related to teaching methods (Friedman et al., 2011) suggested that all the various modalities ranging from computer technologies to demonstrations and reviews of written materials can be effective as long as they are structured and specifically designed for and congruent with the patient's culture. More recently, Sawyer et al. (2016) tested a tablet-based education program for patients with heart failure. They sought to demonstrate the value of the tablet-based education approach to staff and at the same time find ways to minimize the disruptiveness of the technology-based education on clinical workflow, ensure patent safety by establishing specific procedures for device cleaning, and suggest strategies for maintaining the security of the devices. They conclude that technology-based learning tools may be effective in helping patients manage their disease after discharge. They also emphasize the need to consider clinician workflow and device security to ensure a successful implementation.

The next generation, Generation Z, are those born between 1996 and 2010 (Spitznagel, 2020). This generation is growing up in a highly sophisticated and complex digital environment and spending more time with digital devices and the internet than the previous Generation Y. They are also the most ethnically and racially diverse. These individuals are active problem solvers and comfortable and familiar with getting information on demand. They do not like lectures and expect to be able to customize their educational episodes. The teaching strategies should fit with the patient's culture and include using up-to-date instructional technologies, including communication and feedback incorporating social media and smart devices.

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The **HONcode** and **TRUSTe** accreditation symbols are two of the most common symbols that indicate trustworthy and secure websites. Internet users can also look at the **domain name** of the website as a clue to trustworthiness. Many users gravitate toward university sites (.edu), government sites (.gov), and HCO sites (.org). Remember that commercial sites (earn money from advertisers and seek to sell products or services) will use the (.com) domain name and may or may not have credible information to share.

The National Library of Medicine and the NIH jointly sponsor MedlinePlus (https://medlineplus.gov), a website that has a tutorial for learning how to evaluate health information and an electronic guide to web surfing that is available in both English and Spanish. A similar guide explains the major things one should evaluate when accessing health-related resources on the web (National Center for Complementary and Integrative Health, 2018). Suggest that patients visit these sites to become more adept at identifying whether a website is credible before they adopt the recommendations provided.

Some healthcare professionals have partnered with their organizations to develop patient education materials. These materials must be carefully reviewed for accuracy and usability. The Agency for Healthcare Research and Quality (2014) published an assessment tool for both print and audiovisual patient education materials. Its tool is designed to assess both understandability and actionability by providing a series of review criteria for each of these domains. Clearly, clinicians need to engage patients to partner with them in the management of their health. Refer to **Box 16-4** and **Box 16-5** to review effective education methods used in teaching patients and their families about their health challenges.

BOX 16-5 A CLINICIAN'S VIEW ON PATIENT EDUCATION

Denise D. Tyler

Knowledge dissemination in nursing practice includes sharing information with patients and families so that they understand their healthcare needs well enough to participate in developing the plan of care; make informed decisions about their health; and, ultimately, comply with the plan of care, both during hospitalization and as outpatients.

There are several effective methods for educating patients and their families. One-on-one and classroom instruction are traditional and valuable forms of education. One-on-one education is interactive and can be adjusted at any time during the process, based on the needs of the individual patient or family; it can also be supplemented by written material, videos, and web-based learning applications. Classroom education can be beneficial because patients and families with similar needs or problems can network, thereby enhancing the individual experience. However, the ability to interact with each member of the group and tailor the educational experience based on individual needs may be limited by the size and dissimilarities of the group. Individual follow-up should be available when possible.

Paper-based education that is created, printed, and distributed by individual institutions or providers can be very effective because materials can be distributed at any time and reviewed when the patient feels like learning. Many agencies, such as the CDC, have education for patients available on their websites. These documents can be reviewed online or printed by healthcare providers or patients. Organizations can also develop and distribute information and instructions specific to their policies and procedures. In addition, printed educational material can be purchased from companies that employ experts in the subject matter and instructional design.

One of the more popular sources of patient education information is the internet. Many hospitals and HCOs provide proprietary information in this manner, such as directions to the facility, information on procedures, and instructions on what to expect during hospitalization. Other health organizations, such as the NIH, provide detailed information on their websites. Clinicians should be cautious when recommending websites to patients and families because not all sites are reliable or valid.

Many companies that provide clinical information systems or electronic health records also include patient education materials linked to the clinical system via an intranet. Thus, standardized instructions that are specific to a procedure or disease process can be printed from this computer-based

application. Discharge instructions that are interdisciplinary and patient specific can often be modified via drop-down lists or selectable items that can be deleted or changed by the clinician. This ability to modify before printing provides more consistent and individualized instruction. The computer-based generation of instruction is preferable to free-text and verbal instruction because it also allows the information to be linked to a coded nursing language and therefore easily used for measurement and quality assurance reporting. Relevant triggers may be embedded in the clinical information systems. For example, when a patient answers yes to a question about current smoking, smoking cessation information should automatically be printed, or a trigger should remind the nurse to explore this topic with the patient and then provide the patient with preprinted information on smoking cessation.

Integration of standardized discharge instructions and patient education into the clinical system is another way to improve the compliance and documentation of education; it also streamlines the workflow of clinicians. Printing the information to give to the patient should be seamless to the clinician who is documenting information into the patient's record. The format should be logical and easy to read. The more transparent the process, the more efficient the system and the easier it is to use for the clinician. What I envision for the future is a system that "remembers" the style of learning preferred by patients and their families, prompts the provider to print handouts, and programs the bedside computer/video education system, based on previous selections and surveys. This interactive patient and family education would be integrated into the clinical system and the patient's personal health record.

Some providers have developed a list of credible websites and apps that are shared with patients or family members. Recommendations for websites might include the U.S. Department of Health and Human Services–sponsored MyHealthfinder site (https://health.gov/myhealthfinder), a website dedicated to helping consumers find credible information on the internet. Other excellent sources of reliable information are the NIH, the CDC, MedlinePlus, and the National Health Information Center (https://health.gov/our-work/health-literacy/resources/national-health-information-center). Some of the apps (found on iTunes for iPhones or Google Play for Android devices) that might be recommended include Mayo Clinic on Pregnancy, WebMD Pain Coach, MyFitnessPal, and Understanding Diseases. These are great examples of the wealth of patient information being developed as apps by hospitals and other

healthcare providers. More apps are being developed every day to engage people in managing and taking control of their health. Perhaps the most important thing that healthcare professionals can stress is that not all apps have credible and valid information. We must encourage our patients to become savvy users of electronic information sources.

Future Directions for Engaging Patients

Predicting future directions for technology-based health education is somewhat difficult because one may not be able to completely envision the technology of the future. One can predict, however, that some current technologies will be used increasingly to support health literacy and new technologies will be developed every day. For example, audio and video podcasts may become more commonplace in health education and be provided as free downloads from the websites of HCOs.

Voice recognition software used to navigate the web may reduce the frustration and confusion associated with attempting to spell complex medical terms. However, the confusion and frustration may increase if the patient or client is unable to pronounce the terms. Voice interactivity should help to reduce the digital access disparity associated with those who have limited keyboard or mouse skills. For those persons with visual impairments, some websites may provide both audio and text information and support increased text size for greater ease of reading (Anderson & Klemm, 2008).

Many websites associated with government and national organizations are also providing multiple-language access to health information and decision support tools (MedlinePlus, n.d.). The multilanguage access broadens the population to whom education can be provided, and the decision support programs allow users to access results that are tailored to their age, risk factors, or disease state (Anderson & Klemm, 2008).

As patient engagement strategies become more commonplace, we will also see a movement toward connected health. Those individuals who are frequent email users may be interested in being able to communicate with physicians and other healthcare personnel via email or a practice portal messaging system rather than the telephone. This idea previously met with some resistance from physicians who perceived email correspondence as bothersome and time-consuming. However, it is possible that work efficiency might

increase if patients and their needs are screened via secure email or message before an office or a clinic visit. For example, as a result of an email correspondence in lieu of an initial office visit, medications could be changed or diagnostic tests could be performed before the office visit. In addition, patients could be directed to an interactive screening form housed on a secure website where they would answer a series of questions that would help them decide whether they should call for an appointment, head for the emergency room, or self-manage the issue. If self-management is the outcome of the screening tool, then the patient or caregiver could be directed to a credible website for more information. The idea is not to interfere with or replace the face-to-face visit but rather to supplement the provider–patient relationship and perhaps streamline the efficiency of healthcare delivery. Interestingly, Diaz (2022) noted that many physicians and healthcare systems are now billing for email correspondence if the correspondence required physician expertise and took more than 5 minutes.

Wearable technologies are becoming increasingly popular among tech-savvy patients. These technologies are promoting a paradigm shift from provider-centric to consumer-centric care.

The most common consumer-based wearables are fitness trackers, but there are no clear guidelines as to how to integrate the data these devices collect into a patient's health record and make them actionable.

Medgadget (2020) announced its breathable, stretchable, electronic fabric for new medical wearables that offers the "potential to monitor the body over extended periods of time in unprecedented ways. The heart's rhythms, flexion of joints, and other biomedical parameters can be tracked with high fidelity and continuously using devices that can conform to the body" (para. 1). The breathability is the key to the success of its product, with the electronics embedded into the stretchable material. This material permits gases "such as volatile organic compounds and sweat to come through thereby allowing it to be worn over the skin for many days" (para. 2). The more we can make our tools easy to comprehend and use, the more engaged and compliant our patients will be in their health and

wellness journey. Virtual and augmented reality tools are increasingly being used for "stress relieving, relaxation, visualization, and guided meditation tools" (Polet, 2022, para. 3). The literature is beginning to reflect an expansion of concepts beyond patient engagement to enablement, empowerment, and action. LeRouge et al. (2022) stated that "the path to empowered activation includes healthy consumers' responses to critical personal assessments, leading to emergent states of engagement, enablement, and empowerment" (p. 2). They defined *engagement* as "individual motivation to participate in self-management behaviors"; *enablement* as "having appropriate knowledge, skills, and abilities to understand one's health condition and make decisions"; and **empowerment** as "a consequence of enablement and engagement and takes a form of an emergent state and process" (p. 3) leading to action.

Summary

The healthcare delivery system is honing its engagement strategies for patient-centered, connected health. Hospitals are using social media to engage and connect with their patients. The consumer empowerment and connected health movement will continue to drive the need for access to quality health education, engagement, and support programs. In an ideal world, practitioners would design educational materials that are user friendly, culturally competent, interesting, dynamic, and interactive and that meet the skills, education needs, and interests of the user.

THOUGHT-PROVOKING QUESTIONS

1. Choose two patient engagement or connectivity tools and discuss specifically how you would use them to deliver care in your practice.
2. Formulate a patient education plan for a common chronic health challenge related to your practice. Provide a rationale for each approach and describe a technology tool you would use to engage and educate the patient and their family.
3. Reflect on connected health potentials in your practice. What are you doing currently that connects and engages your patients in managing their health? Describe in detail what you plan to do in the next 6 months to a year.
4. Explore the *Healthy People 2030* framework (https://health.gov/healthypeople/priority-areas/health-literacy-healthy-people-2030). How would you explain health literacy based on the 2030 goal? Determine and describe in detail several ways to promote health literacy across the life span.

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CHAPTER 17

Using Informatics to Promote Community and Population Health

OBJECTIVES

1. Provide an overview of community and population health informatics.
2. Assess informatics tools for promoting community and population health.
3. Explore the roles of federal, state, and local public health agencies in the development of public health informatics.

KEY TERMS

- Agency for Toxic Substances and Disease Registry (ATSDR)
- Behavioral Risk Factor Surveillance System
- bioterrorism
- Centers for Disease Control and Prevention (CDC)
- community risk assessment (CRA)
- crowdsourcing
- Division of Health Informatics and Surveillance (DHIS)
- National Health and Nutrition Examination Survey
- national health information network
- prevention informatics
- public health
- public health informatics (PHI)
- Public Health Information Network (PHIN)

- public health intervention
- quality, research, and public health (QRPH)
- regional health information exchange
- risk assessment
- social media
- Suicide Prevention Community Assessment Tool
- surveillance
- surveillance data system
- syndromic surveillance
- Youth Risk Behavior Surveillance System

Introduction

The need for informatics tools to promote and support public health has never been more apparent. Note the following global public health crises of the past two decades alone: SARS, MERS, Ebola, H1N1 (swine flu), Zika, and COVID-19.

In the late fall of 2002, severe acute respiratory syndrome (SARS), the first of several novel coronaviruses, appeared in China. By March 2003, SARS had become recognized as a global threat. According to data from the World Health Organization (WHO; 2021), more than 8,000 people from 29 countries became infected with this previously unknown virus, and more than 700 people died. By 2004, the last SARS cases were caused by laboratory-acquired infections. Because of computerized global data collection, the potentially negative effect of a widespread global epidemic was averted. Middle East respiratory syndrome (MERS) emerged in Saudi Arabia in 2012 and was primarily limited to Arabian countries, with a mortality rate of 3 or 4 out of 10 cases (Centers for Disease Control and Prevention [CDC], 2015). In the late fall of 2019, SARS-CoV-2 (COVID-19) emerged in Wuhan, China; spread rapidly around the world; and was declared a pandemic by the WHO on March 11, 2020 (Felman, 2021). This pandemic resulted in lockdowns in many countries with policies for extreme social distancing enforced to slow the spread of the disease.

Previous pandemic declarations had all been related to flu viruses: H1N1 in 1918, H2N2 from 1957 to 1958, H3N2 in 1968, and H1N1 in 2009 (CDC, 2018b). The 2009 H1N1 swine flu outbreak infected 60.8 million people in the United States, with a mortality rate of 0.2% (Hickok, 2020). Klobucista and Renwick (2020) reported that during the 2014 Ebola epidemic, 11,316 people died, with most cases confined to West Africa. As the Zika virus threat emerged, the CDC (2022d) reported that its Emergency Operations Center (EOC)

> *was activated for Zika on January 22, 2016, and moved to a level 1 activation—the highest level—on February 8, 2016. The EOC is the command center for monitoring and coordinating the emergency*

> *response to Zika, bringing together CDC scientists with expertise in arboviruses like Zika, reproductive health, birth defects and developmental disabilities, and travel health.* (para. 1)

The CDC's EOC staff works in collaboration with local, national, and international response partners to analyze, validate, and efficiently exchange information about outbreaks.

As nurses navigated these outbreaks, they appreciated the need for timely information to be shared with the world population as well as with the healthcare workers responsible for caring for them. Modjarrad et al. (2016) reported on a WHO meeting in which participants "recognized that it is not enough for parties to simply agree, in principle, on sharing primary data, as the world must also commit to tackling the technical challenges of implementing data sharing agreements by simplifying and standardizing data capture procedures, assuring data quality, and harmonizing disparate data platforms" (para. 5). These concepts are central to informatics.

The CDC (2022c) public health surveillance center defines **surveillance** as "the collection, analysis and use of data to target public health prevention. It is the foundation of public health practice" (para. 1). The CDC provides interactive databases and surveys, as well as methods, to guide conducting and evaluating surveillance systems and data standardization. In 2018, Lee et al. reported that the CDC had more than 110 surveillance systems, many of them for single diseases or conditions that were added as a need arose, which resulted in poor coordination and burdensome experiences for users.

Many surveillance systems, loosely termed *syndromic surveillance systems*, use data that are not diagnostic of a disease but that might indicate the early stages of an outbreak (see **Figure 17-1**). Outbreak detection is the overriding purpose of **syndromic surveillance** for terrorism preparedness. Enhanced case finding and monitoring the course and population characteristics of a recognized outbreak are also potential benefits of syndromic surveillance. In recent years, new data have been used by public health officials to enhance surveillance, such as patients' chief complaints in emergency departments, ambulance log sheets,

prescriptions filled, retail drug and product purchases, school or work absenteeism, and medical signs and symptoms in persons seen in various clinical settings. With faster, more specific, and more affordable diagnostic methods and decision support tools, timely recognition of reportable diseases with the potential to lead to a substantial outbreak is now possible. Tools for pattern recognition can be used to screen data for patterns needing further public health investigation. For example, during the 2003 SARS epidemic, the **Centers for Disease Control and Prevention (CDC)** worked to develop surveillance criteria to identify persons with SARS in the United States, and the surveillance case definition changed throughout the epidemic to reflect increased understanding of SARS (CDC, 2017). At this writing, COVID-19 surveillance is ongoing and consists of several data sources, including but not limited to virus and flu surveillance systems, academic systems, case reporting systems, research labs, and commercial testing labs. The CDC (2023b) lists the following goals for COVID-19 surveillance:

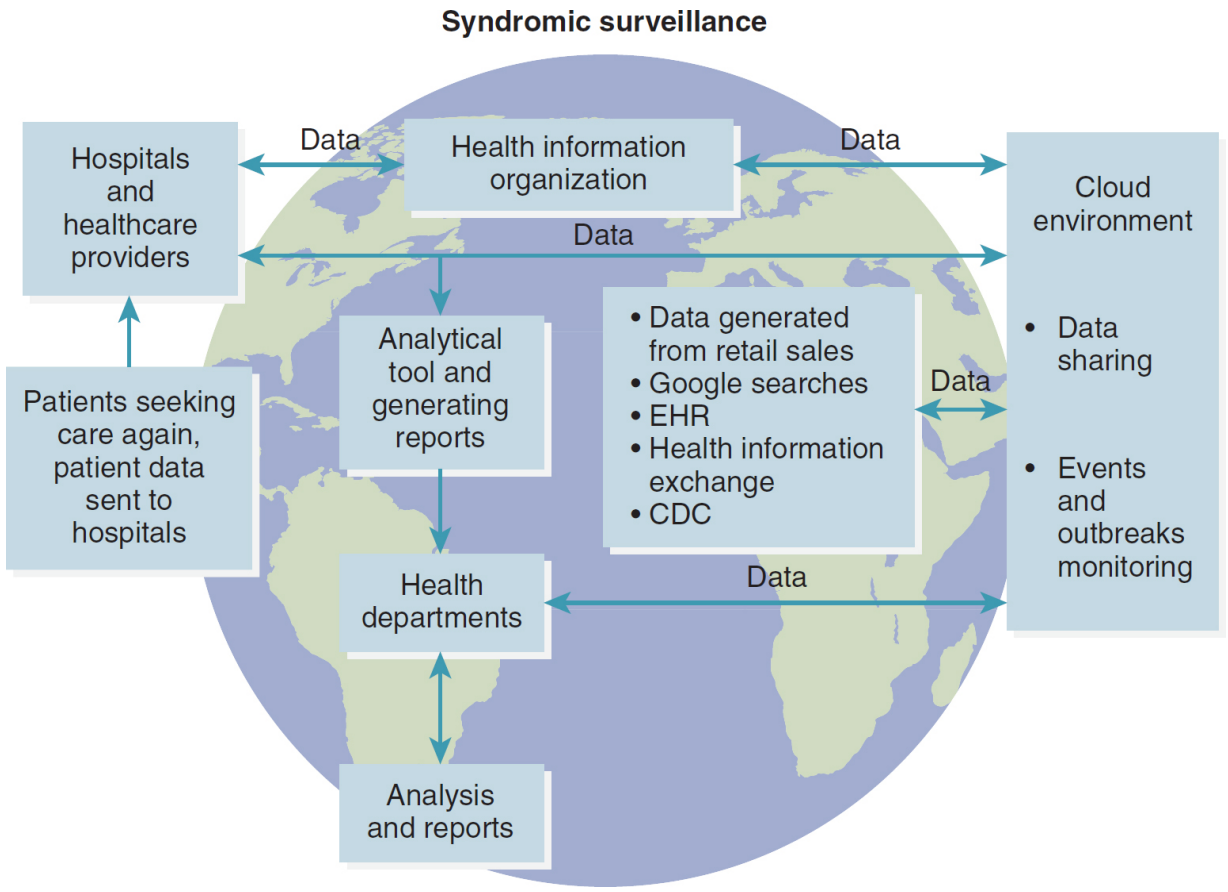


Figure 17-1 Syndromic Surveillance System

Description

- To monitor spread and intensity of COVID-19 disease in the United States
- To understand disease severity and the spectrum of illness
- To understand risk factors for severe disease and transmission
- To monitor for changes in the virus that causes COVID-19
- To estimate disease burden
- To produce data for forecasting COVID-19 spread and impact (para. 3)

Information acquired by the collection and processing of population health data becomes the basis for knowledge in the field of public health. There is an ever-increasing need for timely information about the health of communities, states, and countries.

Knowledge about disease trends and other threats to community health can improve program planning, decision-making, and care delivery. Patients seen from the perspective of major health threats within their communities can benefit from opportunities for early intervention.

This chapter focuses on the application of informatics methods to public health surveillance. The availability of clinical information for public health has been fundamentally changed by the introduction of the electronic health record (EHR) and health information technology (IT), both of which allow for the efficient collection and sharing of data that can be "leveraged for quality improvement and prevention activities" (HealthIT.gov, 2023a, para. 1).

Public Health Essential Services

Public health focuses on health promotion and disease prevention. According to the CDC Foundation (n.d.),

> *[p]ublic health is the science of protecting and improving the health of people and their communities. This work is achieved by promoting healthy lifestyles, researching disease and injury prevention, and detecting, preventing and responding to infectious diseases.*
>
> *Overall, public health is concerned with protecting the health of entire populations. These populations can be as small as a local neighborhood, or as big as an entire country or region of the world.* (para. 1–2)

In the late 1980s the core public health functions were identified as assessment, policy development, and assurance. However, these categories were so broad that they did not provide direction for public health practitioners. In the 1990s, a task force identified 10 essential services of public health, which better defined how local health departments could protect community health (Correll, 2022).

The essential functions as defined by the CDC (2023c) are as follows:

1. Assess and monitor population health status, factors that influence health, and community needs and assets
2. Investigate, diagnose, and address health problems and hazards affecting the population
3. Communicate effectively to inform and educate people about health, factors that influence it, and how to improve it
4. Strengthen, support, and mobilize communities and partnerships to improve health
5. Create, champion, and implement policies, plans, and laws that impact health
6. Utilize legal and regulatory actions designed to improve and protect the public's health

7. Assure an effective system that enables equitable access to the individual services and care needed to be healthy
8. Build and support a diverse and skilled public health workforce
9. Improve and innovate public health functions through ongoing evaluation, research, and continuous quality improvement
10. Build and maintain a strong organizational infrastructure for public health (para. 3)

What Is Public Health Informatics?

Historically, Dr. John Snow can be designated as the "father" of **public health informatics (PHI)** (**Figure 17-2**). In 1854, he plotted information about cholera deaths and was able to determine that the deaths were clustered around the same water pump in London. He convinced authorities that the cholera deaths were associated with that water pump; when the pump handle was removed, the cholera outbreak ended. It was Dr. Snow's focus on the cholera-affected population as a whole rather than on a single patient, as well as his meticulous collection and plotting of data, that led to his discovery of the source of the cholera outbreak (Boston University Medical Campus, n.d). Notice the relationship to the DIKW (data, information, knowledge, and wisdom) paradigm: *Data* were collected and interpreted (*information*), and *knowledge* was generated that led to a wise decision (*wisdom*).

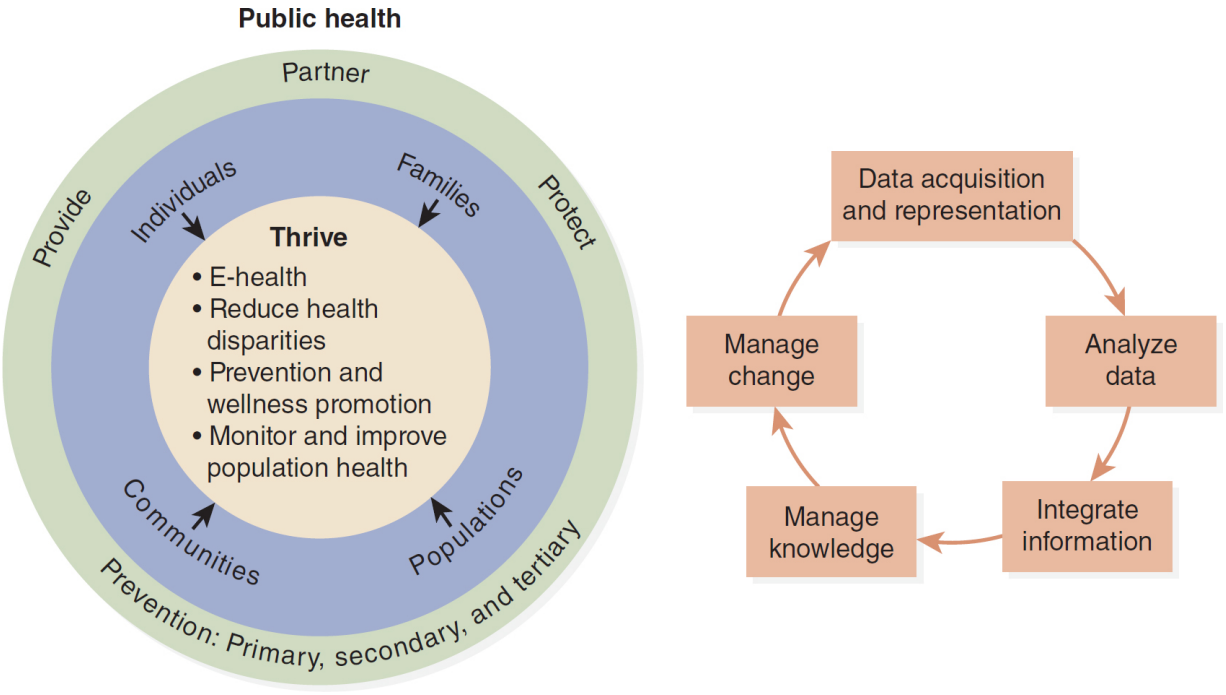


Figure 17-2 Public Health Informatics

Description

Florence Nightingale should also be recognized as an early public health informaticist. Her recommendations about medical reform and the need for improved sanitary conditions were based on data about morbidity and mortality that she had compiled from her experiences in Crimea and England. Her efforts led to a total reorganization of how and which healthcare statistics were collected (Dossey, 2000).

Just as information has been recognized as an asset in the business world, health care is now recognized as an information-intensive field that requires timely, accurate information from many sources. Health information systems address the collection, storage, analysis, interpretation, and communication of health data and information. Many health disciplines, such as medicine and nursing, have developed their own concepts of informatics. That trend has reached the field of public and community health. "When applied to public health, informatics can be used to enable effective monitoring and surveillance, support improved decision-making, and improve population health" (Public Health Informatics Institute, n.d.-b, para. 4). This area of informatics differs from others because it is focused on the promotion of health and disease prevention in populations and communities. PHI efficiently and effectively organizes and manages data, information, and knowledge generated and used by public health professionals to fulfill the core functions of public health: assessment, policy, and assurance. Public health changes the social conditions and systems that affect everyone within a given community. Because of public health initiatives, people understand the importance of clean water, the dangers of secondhand smoke, and that seat belts save lives. Community empowerment can be realized through the collaborative collection and analysis of data that leads to improved community health outcomes and transformed public health.

PHI addresses the data, information, and knowledge that public health professionals generate and use to meet the core functions of public health. Public health initiatives include prevention of epidemics and the spread of disease; protection against environmental hazards; promotion of health, disaster response, and recovery; and provision of access to health care. All these initiatives

are dependent on quality data and information exchange. As the Public Health Informatics Institute (n.d.-b) explained,

> *[p]ublic health informatics assures that the right technologies are used to improve timely delivery of quality data and assists data-driven decision making. It builds bridges across siloed public health work areas by "translating" between these communities, creating opportunities for interoperable information pathways. Ultimately, public health informatics empowers disease interventions and prevention—leading to better health of individuals and the community in which they live.* (para. 4)

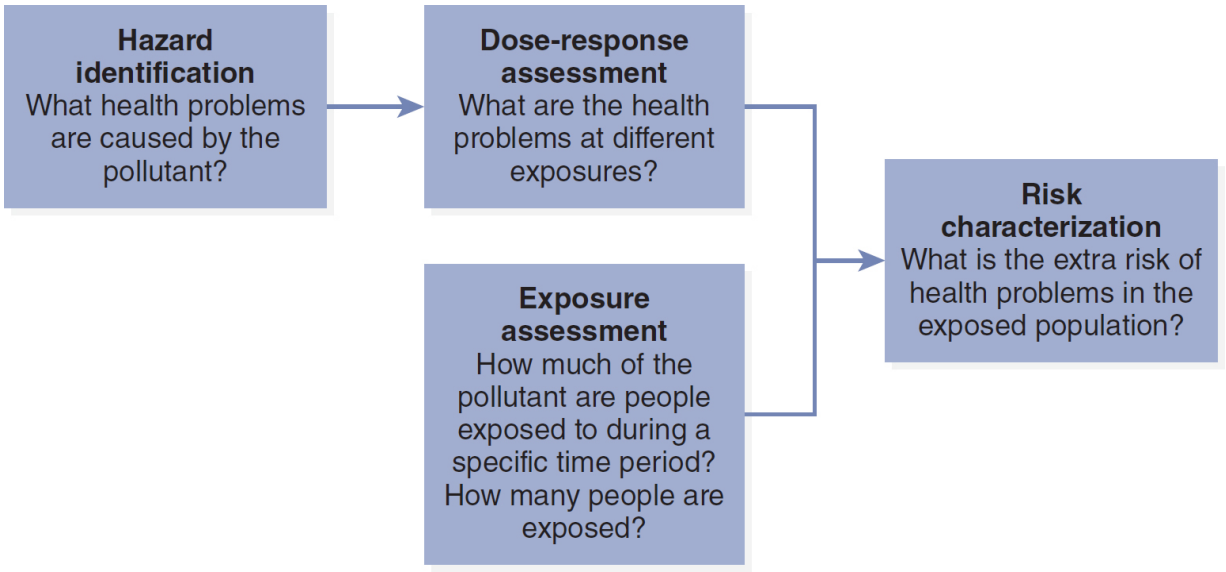
The Integrating the Healthcare Enterprise initiative, to ensure that healthcare information can be shared more easily (using common standards) and used more effectively, has inspired the creation of the domain known as **quality, research, and public health (QRPH)**. Participants in this domain address the repurposing of clinical, demographic, and financial data collected in the process of providing clinical care to the monitoring of disease patterns; incidence, prevalence, and situational awareness of such patterns; and identification of new patterns of disease not previously known or anticipated. Such data can be incorporated within existing public health population analyses and programs for direct outreach and condition management through registries and locally determined appropriate treatment programs or protocols (Integrating the Healthcare Enterprise, n.d.).

Community Health Risk Assessment: Tools for Acquiring Knowledge

As the public has become more aware of harmful elements in the environment, **risk assessment** tools have been developed. Such tools allow assessment of pesticide use, exposure to harmful chemicals, contaminants in food and water, and toxic pollutants in the air to determine whether potential hazards need to be addressed. One such tool is the Public Health Risk Assessment Tool (PHRAT) developed by Drexel University. "The tool defines risk as the expectation of loss from a hazard and calculates risk as the product of a hazard's probability and severity, as measured by its impact across five domains: human health, health care services, inpatient health care infrastructure, community health, and public health services" (Peters et al., 2019, p. S286). Risk factor assessments provide quantitative measures of the effect of a hazard as well as adjusted risk scores, which are calculated based on the relative effect of a hazard in a subpopulation. The PHRAT also measures preparedness based on a public health agency's self-assessment of capability for emergency response and healthcare capacity. The results of the assessment are used "to prioritize planning and plan exercises for specific hazards" (p. S288), such as weather emergencies and outbreaks of infectious diseases.

The U.S. Environmental Protection Agency (EPA; 2023a) "uses risk assessment to characterize the nature and magnitude of risks to human health for various populations—for example residents and recreational visitors, both children and adults. The EPA also estimates risks to ecological receptors, including plants, birds, other wildlife, and aquatic life" (para. 4) and to weigh the benefits and costs of various program alternatives for reducing exposure to potential hazards. It may also influence public policy and regulatory decisions. Health risk assessment is a constantly developing process, based in sound science and professional judgments. There are

usually four steps ascribed to human health risk assessment (**Figure 17-3**):



Modified from: U.S. Environmental Protection Agency. (2016). *Conducting a human health risk assessment*. www.epa.gov/risk/conducting-human-health-risk-assessment.

Figure 17-3 Four-Step Risk Assessment Process

Description

1. *Hazard identification* examines whether a stressor has the potential to cause harm to humans and/or ecological systems and, if so, under what circumstances.
2. *Dose-response assessment* examines the numerical relationship between exposure and effects.
3. *Exposure assessment* examines what is known about the frequency, timing, and levels of contact with a stressor.
4. *Risk characterization* examines how well the data support conclusions about the nature and extent of the risk from exposure to environmental stressors. (EPA, 2023b, para. 2)

The overall question the risk assessment must answer is, "How much risk is acceptable?" Risk factor systems are used throughout the United States and may be local, regional, or national in scope. Specific risk assessment tools exist for specific health issues, such as the **Suicide Prevention Community Assessment Tool**, which addresses general community information, prevention networks, and the demographics of the target population and community assets and risk factors. Other risk assessment tools include the **Youth Risk Behavior Surveillance System**, **Behavioral Risk Factor Surveillance System**, and **National Health and Nutrition Examination Survey**.

Determining the presence of risk factors in a community is a key part of a **community risk assessment (CRA)**. Communities may be concerned about which elements in the environment affect or may affect the community's health, the level of environmental risk, and other factors that should be included in public health planning. The value of a CRA derives from its ability to provide information crucial to planning, build consensus regarding how to mobilize community resources, and allow for comparison of risks with those of other communities. The goal of a CRA is risk reduction and improved health. A CRA may identify unmet needs and opportunities for action, which may help set new priorities for local public health units. It may also be used to monitor the effect of prevention programs.

Processing Knowledge and Information to Support Epidemiology and Monitoring Disease Outbreaks

There is a need to define the role of federal, state, and local public health agencies in the development of PHI and IT applications. The availability of IT today challenges all stakeholders in the health of the public to adopt new systems that can provide adequate disease surveillance; it also challenges people to improve outmoded processes.

Preparedness in public health requires more timely detection of potential health threats, situational awareness, surveillance, outbreak management, countermeasures, response, and communications. Surveillance uses health-related data that signal a sufficient probability of a case or an outbreak that warrants further public health response. Historically, although syndromic surveillance has been used to target investigations of potential infectious cases, its use to detect possible outbreaks associated with **bioterrorism** is increasingly being explored by public health officials (CDC, 2018a). Early detection of possible outbreaks can be achieved through timely and complete receipt, review, and investigation of disease case reports; by improving the ability to recognize patterns in data that may be indicative of a possible outbreak early in its course; and through receipt of new types of data that can signify an outbreak earlier in its course. Such new types of data might include identification of absences from work or school; increased purchases of healthcare products, including specific types of over-the-counter medications; presenting symptoms to healthcare providers; and laboratory test orders. The University of Pittsburgh's Real-time Outbreak and Disease Surveillance Laboratory (RODS), for example, developed the National Retail Data Monitor (NRDM) system. The NRDM collects data on over-the-counter medications and other healthcare products from 28,000 stores and uses computer

algorithms to detect unusual purchase patterns that might potentially signal a disease outbreak (RODS Laboratory, 2020). Keshavamurthy et al. (2022) described the use of infectious disease (ID) prediction models using artificial intelligence (AI) and machine learning processes to provide early warning in disease outbreaks. "By combining robust data collection at the speed of relevance, engineering, and analytic strategies, models can now predict disease event information, such as location, timing, intensity, and the influence of various factors responsible for its occurrence, which can be used to effectively mitigate ID impacts" (pp. 1–2). A comprehensive surveillance effort supports timely investigation and identifies data needs for managing the public health response to an outbreak or a terrorist event. Informatics tools are becoming increasingly important in these public health efforts.

To appropriately process public health data, PHI needs a standardized vocabulary and coding structure. This is especially important as national public health data are collected and data mining performed so that data variables can be understood across systems and between agencies. Health information organizations (HIOs) have been established to support data sharing via health information exchanges (HIEs), as promoted by the meaningful use criteria of the EHR. Central to these initiatives is the need for standardized codes and terminologies that may be used by the HIOs to map data from disparate sources (Hyde et al., 2013; Shapiro et al., 2011). The CDC's **Public Health Information Network (PHIN)** promotes semantic interoperability and secure data exchange among public health information systems. Among the tools and resources managed by this CDC (2022b) division are the following:

- PHIN Vocabulary Access and Distribution System (PHIN VADS)
- PHIN Messaging System
- PHIN Public Health Directory (PHIN DIR)
- PHIN Vocabulary Standards (para. 3–4)

Learn more about these critical initiatives by visiting www.cdc.gov/phin/index.html. In the early 1990s, the CDC launched a plan for an integrated surveillance system that moved from stand-alone systems to networked data exchange built with specific standards. These early initiatives have evolved into a comprehensive system for the collection, processing, and sharing of public health data.

Certainly, the events of September 11, 2001, indicated the need for the United States to increase its efforts directed toward prevention of terrorism and accelerated the need for informatics in public health practice. Today, response requirements include fast detection, science, communication, integration, and action. In 2005, the CDC created the National Center for Public Health Informatics (NCPHI) to provide leadership in the field. This center has since evolved into the **Division of Health Informatics and Surveillance (DHIS)**. The DHIS manages two comprehensive public health surveillance systems, the National Notifiable Diseases Surveillance System (NNDSS) and the National Syndromic Surveillance Program (NSSP), and a data hub for research, the CDC Data Hub. It also develops information systems to support data collection exchange and processing. DHIS's stated mission is to "[p]rovide leadership in surveillance and informatics and support CDC and its partners with state-of-the-art information systems, capacity building services, and high-quality data to guide public health decisions and actions" (CDC, 2022a, para. 2). Learn more about these important services at www.cdc.gov/csels/dhis/strategic-framework.html#Focus-Areas.

The CDC also manages several surveillance systems related to tracking and managing chronic diseases. For example, there are systems for cancer, diabetes, kidney disease, smoking, and pregnancy risk and mortality. Review these systems at www.cdc.gov/chronicdisease/data/surveillance.htm.

Information is vital to public health programming. The data processed into public health information can be obtained from administrative, financial, and facility sources. Included in this data stream may be encounter, screening, registry, clinical, laboratory,

and surveillance data. Public healthcare professionals recommended that the functions of population health beyond surveillance be integrated into the EHR and the personal health record. Such an initiative might allow for population-level alerts to be sent to clinicians through these electronic record systems. Systems now being developed allow for automated syndromic surveillance of emergency department records and media surveillance, which in turn supports early detection of potential pandemic occurrences. Such systems were tested during the 2009 H1N1 flu, 2014 Ebola, and 2015 Zika outbreaks and were certainly utilized during the COVID-19 crisis to track incidence. The public health–enhanced electronic medical record can provide immediate detection and reporting of notifiable conditions. The incorporation of geographic information systems allows public health data to be mapped to specific locations, which may indicate an immediate need for intervention (CDC, 2019a; Grannis & Vreeman, 2010). Modernization of data collection and analysis systems can "engage robustly with healthcare, communicate meaningfully with the public, improve health equity, and have the means to protect and promote health" (CDC, 2023d, para. 2).

Vital statistics databases (e.g., births, deaths, and cancer diagnoses) from state and local governments are also used for public health purposes. It should be noted that databases created with public funds are public databases that are readily available for use (CDC, 2023a). Access these data via the CDC Wide-ranging ONline Data for Epidemiologic Research (CDC WONDER) program at https://wonder.cdc.gov.

The widespread implementation of EHRs is facilitating the concept of a bidirectional public health–enabled record, which can automatically send patient information alerts from the point of care to public health departments when reportable symptoms, conditions, or diseases are encountered as well as allowing public health information and recommendations for treatment to be accessible at the point of care. Kruse et al. (2018) conducted a systematic review of the literature on the effects of EHRs on population health and found that EHR use supported population health by increasing

productivity of practitioners, promoting surveillance for chronic diseases and health promotion activities, and supporting more comprehensive documentation and data sharing. During the COVID-19 pandemic, Reeves et al. (2020) described how a team at one academic health center built and implemented EHR applications to help manage the pandemic. Among the tools the team built were screening protocols, EHR templates, and department-specific order panels that could be modified in real time as learning about the virus continued; reporting and analytics functions; secure communication and messaging functions; and optimizing patient-facing technologies to support telemedicine visits. The health center team concluded that "[t]he electronic health record and associated technologies are vital and requisite tools in supporting outbreak management that should be leveraged to their full potential, and we hope that our experiences in developing these tools will be helpful to other health systems facing the same challenge" (p. 16).

Potential applications of HIE to public health have been described by HealthIT.gov (2023d) and Shapiro et al. (2011). These applications include syndromic surveillance using data generated from mandated and nonmandated laboratory results, physician diagnoses, and emergency or clinic chief complaints; strategies to locate loved ones in mass-casualty events; and public health alerts at the individual and population levels. There were three main types of HIE identified by HealthIT.gov (2023b):

1. Directed exchange is used by a provider to send secure patient information to another provider.
2. Query-based exchange allows a provider to search for health information on a patient in an unplanned healthcare encounter, such as an emergency room visit.
3. Consumer-mediated exchange allows patients to securely manage their information online and share it as they choose. (para. 1)

HIE supported by an EHR resulted in better reporting rates for notifiable diseases (e.g., sexually transmitted infections and

hepatitis): "The results of the study indicate that electronic, pre-populated case reporting forms integrated into providers' EHR systems and workflow, enabled by an interoperable HIE network, can be effective at increasing clinic reporting rates" (Dixon et al., 2019, para. 10).

Applying Knowledge to Health Disaster Planning and Preparation

The availability of data and the speed of data exchange can have a significant effect on critical public health functions, such as disease detection and monitoring, syndromic surveillance, timely intervention, and overall public health planning. PHI makes real-time surveillance data available electronically, and investigations and emergencies can be managed with the tools of informatics. **Surveillance data systems**, such as infectious disease trackers, which collect data on adverse health effects, are invaluable tools for public health officials to tap for planning, evaluation, or implementation of **public health interventions**. The **Agency for Toxic Substances and Disease Registry (ATSDR)**, for example, is a federal agency that acts as a repository for research and data regarding hazardous materials. It serves the public "by responding to environmental health emergencies; investigating emerging environmental health threats; conducting research on the health impacts of hazardous waste sites; and building capabilities of and providing actionable guidance to state and local health partners" (ATSDR, 2023, para. 1). Prior to the 2009 H1N1 pandemic, there was no common infrastructure to respond to pandemics, but the development of health IT is creating opportunities that go far beyond national boundaries to affect global public health initiatives. In May 2017, the WHO released an updated report (previous versions were released in 2009 and 2013) titled "Pandemic Influenza Risk Management," with the goal of informing and harmonizing national and international pandemic preparedness and response. In a similar vein, the U.S. Department of Health and Human Services (2017) released a pandemic influenza plan designed to direct planning for 10 years. The plan detailed seven domains for action:

1. Surveillance, Epidemiology, and Laboratory Activities
2. Community Mitigation Measures

3. Medical Countermeasures: Diagnostic Devices, Vaccines, Therapeutics, and Respiratory Devices
4. Health Care System Preparedness and Response Activities
5. Communications and Public Outreach
6. Scientific Infrastructure and Preparedness
7. Domestic and International Response Policy, Incident Management, and Global Partnerships and Capacity Building (pp. 5–6)

In New York City, a primary care information project, funded by the CDC, developed a multifaceted initiative, the Center of Excellence in Public Health Informatics, to address issues of measurement of meaningful use, disease and outbreak surveillance, and decision support alerts at the point of care (Hripcsak, n.d.). As a result of the continued learning prompted by the COVID-19 pandemic, we can expect to see even more knowledge tools being developed and shared in the near future.

Informatics Tools to Support Communication and Dissemination

The revolution in IT has made the capture and analysis of health data and distribution of healthcare information more achievable and less costly. Since the early 1960s, the CDC has used IT in its practice, and PHI emerged as a specialty in the 1990s. PHI has become more important with improvements in IT; changes in the care delivery system; and the challenges related to emerging infections, resistance to antibiotics, and the threat of chemical and biological terrorism. Two-way communication between public health agencies and community and clinical laboratories can identify clusters of reportable and unusual diseases. In turn, health departments can consult on case diagnosis and management, alerts, surveillance summaries, and clinical and public health recommendations. Ongoing healthcare provider outreach and education and 24-hour access to public health professionals may lead to the discovery of urgent health threats. The automated transfer of specified data from a laboratory database to a public health data repository improves the timeliness and completeness of reporting notifiable conditions.

Public health information systems represent a partnership of federal, state, and local public health professionals. Such systems facilitate the capture of large amounts of data, rapid exchange of information, and strengthened links among these three system levels. Dissemination of prevention guidelines and communication among public health officials, clinicians, and patients have emerged as major benefits of PHI. IT solutions can be used to provide accurate and timely information that guides public health actions. In addition, the internet has become a universal communications pathway and allows individuals and population groups to be more involved and to take greater responsibility for management of their own health status. Ghio et al. (2021) conducted a systematic review

to gather evidence of quality public health messaging. They emphasized that

> *[m]iscommunication or contradictions can result in lower compliance of preventative behaviours. Literacy is fundamental to the understanding and acceptance of any public health messaging campaign. Therefore, public health messaging should focus on clarity, simplicity, transparency and unified messaging even if tailoring to different groups regardless of the level of literacy. Even when the message is understood, different populations have different barriers to address in order to change behaviour.* (p. 6)

The COVID-19 pandemic has sparked innovation in the use of informatics tools for managing the health system's response to the outbreak. As Raths (2020) reported, "In an April 9 AMIA [American Medical Informatics Association] presentation, executives describ[ed] the role clinical informatics is playing in the rapid switch to virtual care as well as public health data sharing and the creation of dashboards and registries. A common theme was that the rapid spin-up of solutions was possible because of years of work creating the informatics framework and developing standards" (para. 1). Here are examples of some of the innovations reported during the pandemic: Artificial intelligence tools have been used to screen lung scans for evidence of COVID-19–specific lung lesions and predict outbreak hot spots and resurgence by analyzing HIE and **social media** data; AI-based chatbots have been used to screen and triage callers to health systems after hospital lines were unable to keep up with calls; robots, facial thermal scan cameras, and no-contact infrared sensor systems were used for temperature screening to detect people with fevers and prevent or triage for hospital visits; and many systems have ramped up their use of telehealth both in and outside the hospital to minimize face-to-face interactions and save scarce personal protective equipment (McCall, 2020; Wittbold et al., 2020). As Wittbold et al. summarized, "While we race to dampen the virus's spread, we can optimize our response mechanisms, digitizing as many steps as possible. This is because traditional processes—those that rely on people to function in the critical path of signal processing—are constrained by the rate at which we can train,

organize, and deploy human labor" (para. 8). Stay tuned for a literal digital transformation of health care in response to this pandemic. Now more than ever, we will need informatics-trained public health professionals.

Few long-term public health professionals have received formal informatics training. There is evidence, however, that informatics competency is increasingly emphasized in academic programs that prepare public health practitioners (Wholey et al., 2018). Public health practitioners are dependent on data and information to inform and perform their practice. In 2016, the Public Health Informatics Institute (n.d.-a) published the Applied Public Health Informatics Competency model, which "frames the knowledge, skills, and abilities that public health practitioners need to address the informatics challenges at their agencies" (p. 2). Key components of this model include the following:

1. Principles and Strategy: Ability to apply informatics principles and strategic thinking to public health information needs, ensuring organizational strategic alignment.
2. Standards and Interoperability: Applies informatics standards to ensure interoperability between disparate information systems.
3. Project Management: Practices project management techniques to engage stakeholders and achieve needs and expectations.
4. Information Systems: Fundamental knowledge of hardware, software and network infrastructure essential to ensuring that public health requirements are met.
5. Communication: Practices active, effective communication between IT, public health and other relevant stakeholders.
6. Evaluation: Applies rigorous methods to evaluate the effectiveness of workflows and information technology.
7. Analysis, Visualization, and Reporting (AVR): Translates data to information and knowledge that leads to action.
8. Policy: Ensures that information projects adhere to relevant laws, rules and regulations. (pp. 3–10)

Access the full model here for explanatory statements related to each of the competencies listed: https://phii.org/wp-content/uploads/2021/06/Applied-Public-Health-Informatics-Competency-Model.pdf.

Using Feedback to Improve Responses and Promote Readiness

Improvement of community health status and population health depends on effective public and healthcare infrastructures. In addition to information from public health agencies, there is now interest in the capture of information from hospitals, pharmacies, poison control centers, laboratories, and environmental agencies. Timely collection of such data allows for early detection and analysis, which can increase the rapidity of response with more effective interventions. Great strides have been made toward a national public health information system, but informaticists currently are still striving to make this a reality. Initially, there was a 10-year vision to achieve an interoperable health IT infrastructure in the United States (HealthIt.gov, 2014). In 2022, the Office of the National Coordinator for Health Information Technology (2022) released the 2022 Interoperability Standards Advisory: www.healthit.gov/isa/sites/isa/files/inline-files/2022-ISA-Reference-Edition.pdf. We have yet to fully achieve the 10-year interoperability goal.

Population health data must be considered an important part of the infrastructure of all **regional health information exchanges**, which are the building blocks for a **national health information network**. Organizations and agencies interested in promoting and protecting the public's health must commit to collaboration and seamless data sharing (HealthIt.gov, 2014). Public health data include data related to surveillance, environmental health, and preparedness systems as well as client information, such as data from immunization registries and laboratory results reporting and analysis. These types of data can provide information about outbreaks, patterns of drug-resistant organisms, and other trends that can help improve the accuracy of diagnostic and treatment decisions and advance public health research (National Institutes of

Health, n.d.). A regional HIE and national health information network can also support public health goals through broader opportunities for participation in surveillance and prevention activities, improved case management and care coordination, and increased accuracy and timeliness of information for disease reporting. In 2019, HealthIT.gov released the second draft of the Trusted Exchange Framework and Common Agreement (TEFCA) and, in 2022, the Qualified Health Information Network framework (QHIN) to promote electronic health information exchange across disparate systems. For more complete information about the TEFCA, access the user's guide here: www.healthit.gov/sites/default/files/page/2019-04/TEFCADraft2UsersGuide.pdf.

Much public health information is focused on reaction to issues and timely intervention rather than on harnessing information technology for disease prevention. As early as 2011, Fuller advocated for a shift to **prevention informatics** by harnessing real-time social data and aggregating and representing these data in a meaningful way so that an appropriate prevention response can be mounted. For example, internet searches related to flu symptoms might prompt a public health prevention response, such as a school closure, to minimize spread. A software tool that supports mapping and real-time data visualization is Ushahidi, which supports "gathering of distributed data from the web and other data streams" (Fuller, 2011, p. 40). "Prevention informatics offers a useful paradigm for re-imagining health information systems and for harnessing the vast array of data, tools, technologies and systems to respond proactively to health challenges across the globe" (Fuller, 2011, p. 41).

Harnessing data from social media, such as X (Twitter) and Facebook, provides yet another example of using citizen-generated information (i.e., **crowdsourcing**) in community health. Merchant et al. (2011) described how mining data generated in social media can improve the response to mass disasters by helping responders locate people who require help and identifying areas that need resources, building social capital, and promoting community resilience after the disaster. "Tweets and photographs linked to

timelines and interactive maps can tell a cohesive story about a recovering community's capabilities and vulnerabilities in real time" (Merchant et al., 2011, p. 291). These authors cautioned, however, that social media should be used to augment—not replace—current disaster response and communication systems because not all communications in social media are entirely trustworthy. In addition to utilizing social media posts, Benforado's (2015) presentation to the EPA on Citizen Science and Crowdsourcing asked the question, "If you had 100,000 people to help you with your work, what would you do?" (slide 2). Enlisting and empowering people can promote volunteerism and advance science. There is power in investing in citizen science approaches and harnessing the efforts of volunteers. The use of social media data during public emergencies has been variously termed *crisis informatics* or *disaster informatics*. Palen and Anderson (2016) suggested that social media use is important during disaster response because it gives people affected by the disaster a voice and a means to participate in a response.

Reuter and Kaufhold (2018) identified four types of communication capability via social media during a crisis: citizen to citizen (C2C), authorities to citizens (A2C), citizens to authorities (C2A), and authorities to authorities (A2A). Further, they argued that not all social media use during a disaster or crisis is positive, especially in the case of dissemination of false or misleading information. They concluded that "[t]rust is the main issue, so future work might focus on the key enablers, like positive examples of social media use. The feeling to be part of a movement that productively works together to overcome crises and emergencies is the intended result of this" (p. 52). Basch et al. (2022) stated, "Our work indicates that the content of official public health agency social media accounts does not receive as many views as communications posted by popular entertainers, influencers, or, in some cases, even consumers. Partnerships with carefully vetted content creators may help to extend the reach of accurate health information on social media, particularly to young people who tend to use these platforms in higher numbers than older adults" (pp. 3–4). The use of social media during the COVID-19 pandemic increased exponentially.

However, the credibility of the information that is crowdsourced is difficult to discern. During a crisis, it is best to seek information from credible sources, such as the CDC. The CDC can be followed on various social media, such as Facebook, Twitter, and YouTube. It has a comprehensive toolkit guiding the use of social media. Access the Social Media Toolkit here: www.cdc.gov/healthcommunication/toolstemplates/socialmediatoolkit_bm.pdf.

Summary

PHI strives to ensure that evolving health data systems will meet the data needs of all organizations interested in population health as national and international standards are developed for healthcare data collection. The data included in this standardization process are environmental, sociocultural, economic, and other data that are relevant to public health. As a result of the COVID-19 pandemic, PHI will likely garner more widespread appreciation and respect as well as creative innovation that will affect public health initiatives for years to come. **Table 17-1** provides the names, addresses, and URLs for important organizations dedicated to public health data and informatics.

TABLE 17-1 Important PHI Sites

Name	Address	Website
American Public Health Association	800 I Street NW, Washington, DC 20001	www.apha.org
Centers for Disease Control and Prevention	1600 Clifton Road, Atlanta, GA 30333	www.cdc.gov
AHIMA Public Health Data Standards Council	233 N. Michigan Avenue, 21st Floor, Chicago, IL 60601-5809	www.ahima.org
Public Health Institute	555 12th Street, 10th Floor, Oakland, CA 94607	www.phi.org

The future of practice in public health depends on how efficiently and effectively public health data are captured, analyzed, and disseminated for regional, national, and global health planning and management. In an ideal world, we would see seamless data

collection and sharing with a commitment to prevention and global health planning.

THOUGHT-PROVOKING QUESTIONS

1. Imagine that you are a PHI specialist and that you and your colleagues are concerned about the response to the COVID-19 pandemic. Review the public health data that were used to determine the response to the pandemic. Which data would need to be collected to assess the outcomes of the pandemic response?
2. What are the advantages and disadvantages of using crowdsourced social media data during a disaster response?
3. Choose an informatics tool that was developed or modified during the COVID-19 pandemic. Assess its long-term sustainability.

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Centers for Disease Control and Prevention. (2023c). *Public health professionals gateway: 10 essential public health services*. www.cdc.gov/publichealthgateway/publichealthservices/essentialhealthservices.html

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CHAPTER 18

Telenursing and Remote Access Telehealth

OBJECTIVES

1. Explore the use of telehealth technology in nursing practice.
2. Apply the Foundation of Knowledge model to home telehealth.
3. Identify the socioeconomic factors likely to increase the use of telehealth interventions.
4. Describe clinical and nonclinical uses of telehealth.
5. Specify and describe the most common telehealth tools used in nursing practice.
6. Explore telehealth pathways and protocols.
7. Identify legal, ethical, and regulatory issues of telehealth practice.
8. Describe the role of the telenurse.

KEY TERMS

- call center
- central station
- chronic disease
- home health care
- home telehealth care
- medication management device
- patient informed consent
- peripheral biometric (medical) device
- personal emergency response system

- portal
- real-time telehealth
- sensor and activity-monitoring system
- store-and-forward telehealth transmission
- telehealth
- telehealth care
- telemedicine
- telemonitoring
- telenursing
- telepathology
- telephony
- teleradiology
- web server

Introduction

Telehealth refers to a wide range of health services that are delivered by telecommunications-ready tools, such as the telephone, videophone, smartphone, and computer. The telephone, the most basic of telecommunications technologies, has been used by health professionals for many years. For example, nurses may counsel a patient by telephone, or doctors may respond to patient status changes or family requests. Because of these widespread uses, people are already somewhat familiar with the value of the direct, expedient contact that telecommunications-ready tools provide for healthcare professionals. However, physicians and patients alike largely valued traditional face-to-face office visits because of the personal interactions they afforded. In addition, barriers to telehealth included reimbursement, connectivity, and equipment issues. Then, in March 2020, the COVID-19 pandemic surfaced. Roth (2020) provided this insight: "With the arrival of the COVID-19 pandemic, telehealth has finally come of age. Like a lonely teenager who once struggled to make connections with a broader network of friends and was bound by strict parental controls, suddenly, telehealth has blossomed into the most popular kid in school by becoming an essential tool in the healthcare armament against this pandemic" (para. 1). Up until March 2020, Medicare beneficiaries were able to enjoy paid access to telehealth services only if they lived in a rural area and had certain chronic medical conditions. On March 13, 2020, President Trump announced widespread expansion of telehealth services for Medicare beneficiaries and relaxation of rules so that seniors could avoid exposure to COVID-19 in physicians' offices and clinics (Centers for Medicare and Medicaid Services [CMS], 2020b) and virtual consultations could help triage patients for further treatment as necessary. As a result, the demand for telehealth and virtual visits increased exponentially, which taxed a system that was not prepared for this type of growth (Brodwin & Ross, 2020). Several key groups raced to provide the support and

guidance that physicians, nurses, and healthcare systems would need to ramp up their telehealth services by using virtual platforms (i.e., Skype, WebEx, and Zoom), existing patient portals, messaging apps, or phone calls. For example, the American Hospital Association (AHA, 2020) released a best practices document, CMS (n.d.) released the General Provider Telehealth and Telemedicine Tool Kit, and the American Medical Association (AMA, 2023) released the AMA Telehealth Quick Guide (released in 2020 and updated in 2021), all in a matter of a few weeks.

In 2019, the AHA reported that 76% of hospitals used telehealth to provide some services and connect clinicians for consultations at a distance, up from 35% reported in 2010. At the time, the AHA also reported limitations on coverages for Medicare recipients; broadband limitations for patients in rural areas; cross-state licensing issues; and concerns about online prescribing, security, and privacy (AHA, 2019). The growth of telehealth services, prompted by necessity during the COVID-19 pandemic, is leveling off as we emerge from the pandemic (Melchionna, 2022). "In 2022, 38 percent of care was virtual. Researchers expect that in the years to come, telehealth will be optimal not as a replacement to in-person visits but as a complementary service" (Melchionna, 2022, para. 4). This will provide nurses with many future opportunities to contribute to care delivery via telehealth services. Fauteux (2022) called the growth of telehealth the pandemic's silver lining. Let's examine a potential nursing contribution using the Foundation of Knowledge model.

The Foundation of Knowledge Model and Home Telehealth

There is much to learn about usual home telehealthcare service delivery, particularly to the elderly and chronically ill patients. Using the Foundation of Knowledge model is key to learning how to use telehealthcare tools with typical patients (e.g., elderly patients and patients needing pointed care) and to operate effectively as telenurses. To understand the mechanics and effectiveness of home telehealth delivery within the Foundation of Knowledge model, the discussion will begin with a typical home telehealth case, through which the telenurse's role in this model can be explored.

CASE STUDY: THE ROLE OF A HOME TELEHEALTH NURSE

Mrs. A. is an 84-year-old woman who was recently discharged from the hospital with a diagnosis that includes an exacerbation of congestive heart failure (CHF). She also has diabetes and hypertension. Mrs. A. was discharged from the hospital on multiple medications and lives alone.

Home care services were initiated with skilled nursing care visits, some home health aide support, and orders to include daily telemonitoring of her vital signs. The telehealth device will remotely monitor Mrs. A.'s blood pressure, heart rate, oxygen saturation, and weight. In addition, the patient will answer customized questions about her disease on a daily basis. This information will then be transmitted daily to the home care agency, where the telenurse can determine appropriate clinical actions based on the data trends and preset baseline alerts that indicate when set parameters have been exceeded.

Knowledge Acquisition

As the case study illustrates, knowledge acquisition involves the telenurse receiving information from the telehealth devices via a

variety of communication modes. For example, the telenurse receives the patient's vital signs taken in the home and the patient's responses to customized questions. All of this information is transmitted to a remote server or site (i.e., a central station or website) that is easily accessible to the telenurse.

Knowledge Processing

As a result of the telenurse's knowledge acquisition, the next step is knowledge processing (i.e., understanding a set of information and the ways it can be applied to a specific task). In the case study, the telenurse assesses Mrs. A.'s vital signs along with subjective data received from her as a result of the customized questions that she is asked. For example, she might be asked whether she feels shorter of breath on a given day compared to how she normally feels. The telenurse then combines this information with the patient's overall history and diagnosis to get an up-to-date view of the patient's status and considers where this information fits into the clinical picture being presented for this patient.

As an example, the telenurse notes the following: Postacute heart failure patient shows trended data with weight gain of 5 pounds over 2 days, elevated blood pressure, and decreased oxygen saturation and answers yes to questions about increased shortness of breath and increased fatigue. After processing all the current information, the telenurse is able to target the next appropriate steps involving knowledge generation and knowledge dissemination.

Knowledge Generation

By using her own nursing skills and clinical knowledge of the disease process, the telenurse considers all the data as they apply to Mrs. A., decides the best course of action to take, and acts on the data. The telenurse may, in addition, ask a variety of questions to ensure that a complete and accurate decision about the next steps for the patient is made. These questions might include the following:

- Do I need to gather additional data?
- Do I need to call the patient?
- Do I need to call the physician and inquire about a change in the current plan of care?

Knowledge Dissemination

Finally, the telenurse determines how the knowledge will be used and disseminated. Various questions that were posed in the knowledge-generation stage are acted on, including the following possibilities:

- Calling the doctor
- Obtaining a change in medication order
- Calling the patient and instructing her in a medication change
- Reviewing activities that could have led to the changes (e.g., eating salty foods)
- Educating the patient on the disease process, symptom management, and self-management techniques
- Continuing to monitor the patient on an ongoing basis

As the case illustrates, the nurse used various technologies to acquire data; interpreted the meaning of the data, thus generating information and knowledge; and then used that knowledge and wisdom to intervene appropriately.

Nursing Aspects of Telehealth

Understanding telehealth and the potential use of telehealth technology in nursing practice is necessary in today's changing healthcare arena. As this chapter describes, nurses using telehealth have much greater access to their patients' conditions and needs and are able to respond in a timelier way than is possible using only face-to-face visits. Patients' responses to new medications, for example, can be tracked within hours rather than the several days that elapse between face-to-face visits. The telecommunications-ready tools that can be used to achieve these results are described here, and cases that have demonstrated successful outcomes are highlighted.

Telehealth is still a new and evolving technology; while the off-site interventions or contacts often lead to less time being wasted on non–care-oriented tasks because of the efficiencies offered by the technology applications, its use must never be associated with less care. It is also important to note that nursing activity in telehealth still follows the same best practice standards as those espoused in conventional care. One should simply look at the use of telehealth tools as a means for nurses to do their work better.

As the case study demonstrated, a home healthcare nurse working with telehealth tools was able to detect and respond to a patient's condition more expediently than if the nurse had relied solely on scheduled home visits and thus was able to intervene to prevent a potentially serious deterioration in the patient's condition.

History of Telehealth

In the early 1960s, President John F. Kennedy gave the National Aeronautics and Space Administration the goal of landing an American on the moon. A surprise benefit of the space program was the demonstration of effective remote monitoring of the astronauts; thus, modern telehealth was born.

Although most of the advances in telehealth have taken place in the past 30 years, Craig and Patterson (2005) described much earlier examples, such as the use of bonfires to alert neighboring villages of the arrival of bubonic plague during the Middle Ages. Postal services and telegraphs were used to transmit health information in the mid-19th century, and 1910 marked the first transmission of stethoscope sounds over a telephone. Radio communications were used to provide medical support for crews on ships; the Seaman's Church Institute of New York (1920) and the International Radio Medical Center (1938) are two examples of organizations founded to provide health support at a distance. These services were later expanded to cover air travel (Craig & Patterson, 2005). As technology evolved, its use in health care continued to grow. The first reported use of television to monitor patients in a clinical facility occurred in the 1950s, which then led to the development of interactive closed-circuit applications in the mid-1960s. These early applications of television to health care occurred within the facility but still had the benefit of extending the reach of the caregivers because they did not need to be in the same room as their patients to monitor them effectively (Prial & Hoss, 2009).

In the 1970s, uses of more advanced forms of telehealth in the medical field, referred to as **telemedicine**, included **teleradiology** and **telepathology**—radiological and pathological images transmitted to specialists who were located at some distance (Allan, 2006). As additional specialties, such as dermatology and ophthalmology, entered the telemedicine arena, telehealth use enabled even more physicians to access information about their

patients, regardless of the distances between themselves and the patients and in sites other than conventional healthcare settings.

Success in telehealth was achieved after decades spent refining the technology, which resulted in clearer imaging, speedier transmissions, and accurate replication of data from remote locations to a central hub. The end results of telehealth interactions today have helped to ensure that professionals, whether working off-site or directly with patients, can replicate the usual clinical interactions in all specialties, regardless of the distance involved in the contact.

The ability to provide better healthcare access is the number one benefit of using telehealth. By reducing the need for face-to-face interaction with the patient, the nurse, physician, or technician can be much more productive. When information is collected in the home, it becomes much more convenient for the patient, and the quality and timeliness of the information are improved dramatically. Home telemonitoring should be viewed as an enhancement to care because it allows more direct, physical intervention to occur only when it is actually needed. Care is not directed by a prescheduled appointment or by subjective perceptions of a condition but instead can be determined by objective measures of physical status. With telehealth, care can also be delivered at the most appropriate site of care, which reduces reliance on emergency departments and inpatient facilities (Prial & Hoss, 2009).

Driving Forces for Telehealth

A significant increase is expected in the use of information technology tools in nursing venues in the coming decades, based on several factors in Western society. The following factors are drivers of the growing trend toward telehealth and technology use and will influence nursing practice significantly in the next decades: demographics; nursing and healthcare worker shortages; chronic diseases and conditions and the pandemic; the new, educated consumers; and excessive costs of healthcare services that are increasing in need and kind.

Demographics

One significant factor is that the baby boomers are getting older and people are living longer. In 2000, 13% of the U.S. population was older than age 65, and the number of older adults continues to grow significantly each day. According to the U.S. Census Bureau (n.d.), every day, 10,000 people turn 65. Consequently, by 2030, 19% of the U.S. population will be 65 years old or older, and the oldest-old (85 years or older) will increase by 3 million persons between 2010 (5.8 million) and 2030 (8.7 million; Vincent & Velcoff, 2010). Also on the rise is the number of older Americans living with at least one chronic disease or condition. The National Council on Aging (2023) reported that nearly 95% of older adults have at least one chronic illness and nearly 80% of the U.S. population over age 65 have two or more chronic illnesses. This trend should alert clinicians to the much greater demand for planned professional care that will arise in the coming years.

CASE STUDY: EARLY DETECTION OF A CHANGE IN CONDITION

Mrs. C., an independent 96-year-old woman, has a history of rehospitalization because of atrial fibrillation, which resulted from CHF and hypertension.

After her most recent hospitalization, Mrs. C. was treated and released into home care at an agency in Washington. A home telemonitoring system that tracks and transmits patients' vital signs was placed in her home. The primary goal of placing this patient on the telemonitor was to provide daily monitoring of her condition, thereby avoiding unnecessary rehospitalizations.

One morning, Mrs. C.'s telenurse detected an alarmingly low oxygen saturation level in the patient's transmitted data. In response, the nurse telephoned Mrs. C. and asked her to retake her oxygen reading. The reading was confirmed, and the telenurse contacted the patient's physician, who requested immediate transportation of the patient to the hospital emergency room. Medics were called, and Mrs. C. was taken to the hospital, where she was diagnosed with a pulmonary embolism.

The prompt response resulted from early detection and timely intervention enabled by the home telehealth equipment and a home health nurse's oversight. One notable fact in this case is that although the primary goal of monitoring patients is to avoid unnecessary hospitalization, in this case the hospitalization was necessary for the patient as a result of her elevated blood pressure and compromised oxygen saturation levels. The patient was still asymptomatic at the time of detection. However, the telehealth intervention and subsequent hospitalization allowed for the embolism to be treated before any serious damage had occurred.

Under the traditional home care model, this patient might have been seen by a nurse only two or three times per week, and the clinician would not have knowledge of the patient's condition in between visits. However, having vital patient data tracked and transmitted daily allowed for a rapid response, which resulted in a positive outcome, perhaps a lifesaving intervention for this patient.

Nursing and Healthcare Worker Shortages

The crisis related to the well-known nursing shortage has two key aspects: a greater need for nurses by more persons, particularly those living with multiple comorbidities, and a significant decrease in the number of young people entering the nursing profession. Nationwide, the demand for nurses is clearly exceeding the supply. The American Association of Colleges of Nursing (AACN, 2022) reported, "The U.S. is projected to experience a shortage of

Registered Nurses (RNs) that is expected to intensify as Baby Boomers age and the need for health care grows. Compounding the problem is the fact that nursing schools across the country are struggling to expand capacity to meet the rising demand for care given the national move toward healthcare reform" (para. 1). The AACN projected a 6% increase in the nursing workforce between 2021 and 2031 and a need for 203,200 new RNs per year.

The very serious shortage of healthcare workers in the United States must be addressed with some foresight. Although there is currently more focus on training laypeople, such as aides and other paraprofessionals, to perform certain nursing tasks, this venture certainly cannot replicate the clinical expertise of trained nurses skilled in nursing science. We must begin to look seriously at using effective adjuncts to skilled care, with telehealth being one of these important developments. Some organizations have already begun to do so.

Chronic Diseases and Conditions

Today, chronic conditions are the leading cause of illness, disability, and death in the United States. The number of elderly persons living with **chronic disease** is estimated at 140 million in the United States and accounts for more than 80% of healthcare expenditures (Dorsey & Topol, 2016). Both chronic conditions and the number of persons with chronic illnesses are expected to increase dramatically in the United States in the next few decades. Many age groups are also affected by chronic disease, not just the elderly. As noted in a report from the Centers for Disease Control and Prevention (CDC, 2022), 6 in 10 adults in the United States have a chronic disease, and 4 in 10 have two or more (para. 1). Note that this statistic is referring to adults of any age, when earlier in the demographics section we reported on chronic diseases for the aging population. You can follow the CDC's chronic disease surveillance activities at this website: www.cdc.gov/chronicdisease/data/index.htm.

Securing appropriate, adequate, and affordable care services for these populations should be a national concern.

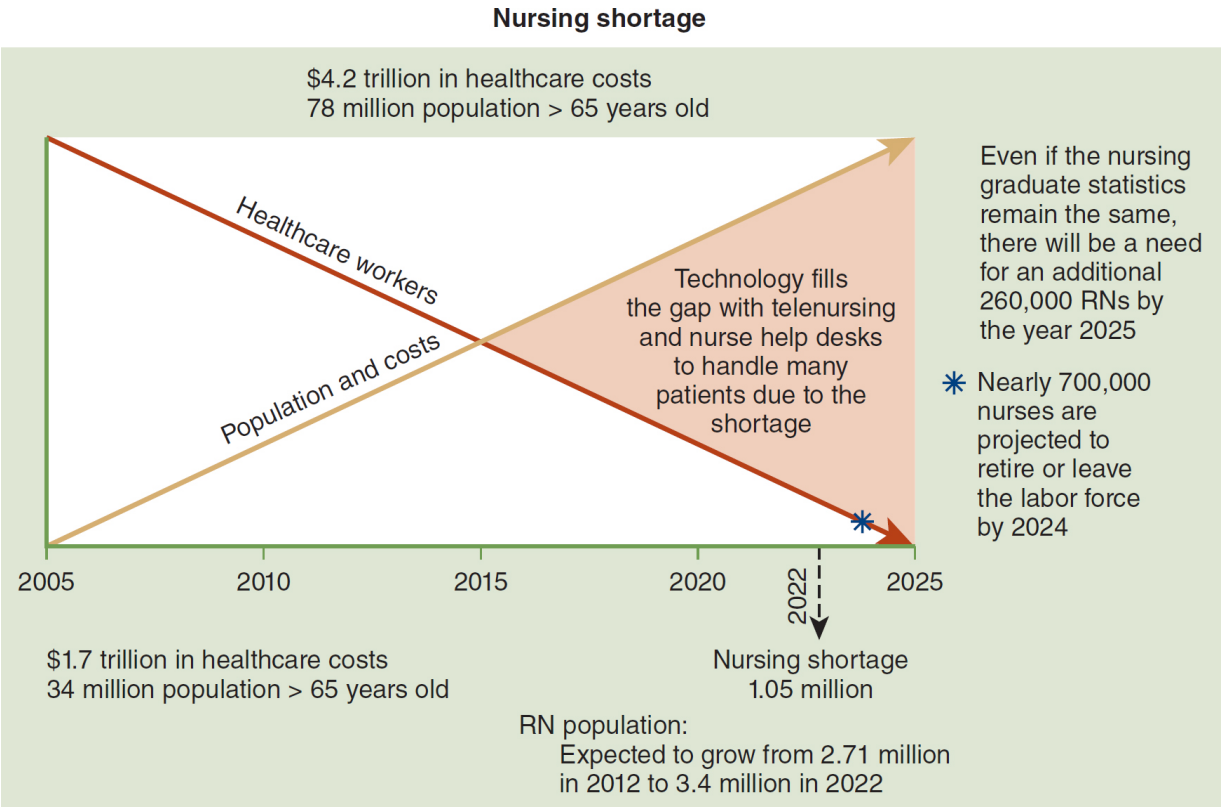
Educated Consumers

The wave of today's aging baby boomers is steering some of the usual health service practices toward a very different course. Many of these individuals are more educated than their parents and more comfortable with the use of technology. They want to become more informed and involved with their care plans. These empowered consumers will be financially motivated with the introduction of consumer-directed healthcare plans that reward healthier lifestyles and better disease management of chronic conditions. All these circumstances will further drive the use and innovation of new technologies to meet consumer need. New plans for this new generation of consumers very much lean toward meeting their demands for when-needed, as-needed care, or care services delivered on their own terms and timing.

Economics

When the drivers of today's healthcare market—the demographics, nursing shortages, and increased number of persons living with chronic conditions and their extensive use of healthcare services—relate to excessive costs of this health care, the critical need for solutions becomes obvious. The CMS (2022) reported that "U.S. health care spending grew 2.7 percent in 2021, reaching $4.3 trillion or $12,914 per person. As a share of the nation's Gross Domestic Product, health spending accounted for 18.3 percent" (para. 2). Much more will be spent annually in the coming decades. Taking all the driving factors of today's healthcare market into account, the question must be asked, What needs to be done to address healthcare issues in the United States to meet the burgeoning numbers and needs of patients?

One solution is to develop a new clinical model for U.S. health care that includes technology. Telehealth technology should be included to fill the gap resulting from an overabundance of patients and a scarcity of healthcare providers. This concept is indicated in **Figure 18-1**.



Data from Honeywell.

Figure 18-1 Technology Fills the Gap

Description

Consider the use of technology that might potentially fill the current gaps in the healthcare system. Tools of telehealth can, for example, help render needed services without requiring in-person professional care at all contacts. The remote, or virtual, visit made by skilled clinicians is just one approach to using the range of health technologies available today. More needs to be learned about what

telehealth is, how it works, and which aspects have been successful so that clinicians can plan to incorporate its use into routine clinical care.

Telehealth Care

To begin this discussion, a basic definition of **telehealth care** is needed. The American Telemedicine Association (ATA, n.d.) provided the following definition:

> *In brief, telemedicine is the remote delivery of health care services and clinical information using telecommunications technology. This includes a wide array of clinical services using internet, wireless, satellite and telephone media. (para. 1)*

The Health Resources and Services Administration (2022) offered this definition: "Telehealth is defined as the use of electronic information and telecommunication technologies to support long-distance clinical health care, patient and professional health-related education, health administration, and public health" (para. 1). Indeed, *telehealth* is generally used as an umbrella term to describe all the possible variations of healthcare services that use telecommunications. Telehealth can refer to clinical and nonclinical uses of health-related contacts. Delivery of patient education, such as menu planning for patients with diabetes or the transmission of medication reminders, is an example of the health-promoting aspects of telehealth.

Clinical Uses of Telehealth

A few clinical uses for telehealth technologies and sample clinical applications include the following:

- *Transmitting images for assessment or diagnosis.* One example is transmission of digital images, such as images of wounds for assessment and treatment consults.
- *Transmitting clinical data for assessment, diagnosis, or disease management.* An example is remote patient monitoring and transmitting patients' objective or subjective clinical data, such

as monitoring of vital signs and answers to disease management questions.

- *Providing disease prevention and promotion of good health.* Examples include case management provided via telephone or smartphone app and patient education provided through asthma and weight management programs conducted in schools.
- *Using telephonic or video interactive technologies to provide health advice in emergent cases.* An example is performing teletriage in call centers or real-time stroke consultation between a rural health center and an academic medical center.
- *Using real-time video.* An example is exchanging health services or education live via videoconferences.

Telehealth Transmission Formats and Their Clinical Applications

Nurses must become familiar with the many and varied clinical and nonclinical transmission formats and applications of telehealth technologies so that they can make informed choices about the tools that are available for their use. Among these applications are store-and-forward telehealth, real-time telehealth, remote monitoring, telephony, and mobile health (mHealth). The Center for Connected Health Policy has provided video overviews of the telehealth transmissions and clinical applications. To access these videos, go to www.cchpca.org/resources. Several of the videos posted there reflect telehealth changes in response to the COVID-19 pandemic.

Store-and-Forward Telehealth

In a **store-and-forward telehealth transmission**, digital images, video, audio, and clinical data are captured and stored on the client's computer or device; then, at a convenient time, the data are transmitted securely (forwarded) to a specialist or clinician at another location, where they are studied by the relevant specialist or clinician. If indicated, the opinion of the specialist or clinician is then

transmitted back. Based on the requirements of the participating healthcare entities, this round-trip interaction could take anywhere from a few minutes to 48 hours. In many store-and-forward specialties, such as teleradiology, an immediate response is not critical. Dermatology, radiology, and pathology are common specialties whose practices are conducive to store-and-forward technologies. Transmission of wound care images for assessment by specialty care nurses or other specialists has become a frequently used and important form of home telehealth nursing practice.

Real-Time (or Interactive) Telehealth

In **real-time telehealth**, a telecommunications link between the involved parties allows a real-time, or live, interaction to take place. Videoconferencing equipment is one of the most common forms of technologies used in synchronous telehealth. In addition, peripheral devices can be attached to computers or to the videoconferencing equipment to facilitate an interactive examination. Use of computers for real-time two-way audio and video streaming between centers over ever-improving and cheaper communication channels is becoming common. These developments have contributed to the lowering of costs in telehealth. See **Figure 18-2** for a depiction of this interaction.



Reproduced from: Ohio Supercomputer Center. (2008). *Governor Strickland, international panel of experts consider establishing telehealth video resource center*. www.osc.edu/press/governor_strickland_international_panel_of_experts_consider_establishing_telehealth_video.

Figure 18-2 Physician-to-Physician Consult Using Telehealth

Examples of real-time clinical telehealth applications include the following:

- Telemental health, which uses videoconferencing technology to connect a psychiatric nurse with a mental health client.
- Telerehabilitation, which uses video cameras and other technologies to assess patients' progress in home rehabilitation.
- Telehomecare, which uses video technologies to observe, assess, and teach patients living in rural areas.
- Teleconsultations, which use a variety of technologies to enable collaborative exchanges or consultations between individuals or among groups that are involved with a case. These teleconsults may be transmitted live using videoconferencing technology. They may, for instance, involve teaching a certain technique to a less experienced clinician, or they may provide several clinicians with an opportunity to discuss an appropriate approach to a difficult case.
- Telehospice, or telepalliative care, which can use real-time or remote monitoring to provide psychological support to patients and caregivers. Telehealth devices can also play a role in symptom management, in effect helping end-of-life patients achieve an optimal quality of life.

Remote Monitoring (Telemonitoring or Remote Patient Monitoring)

In remote monitoring, devices are used to capture and transmit biometric data. For example, a tele-electroencephalogram device can monitor the electrical activity of a patient's brain and then transmit those data to a specialist assigned to the case. This interaction could occur either in real time or as a stored and then forwarded transmission. Examples of **telemonitoring** include the following:

- Monitoring patient parameters during home-based nocturnal dialysis
- Cardiac and multiparameter monitoring of remote intensive care units (ICUs)

- Home telehealth—for example, daily home telemonitoring of vital signs by patients and subsequent transmission of those data that enables off-site nurses to track their patients regularly and precisely and address noticeable changes through education and information suggestions about diet or exercise
- Disease **management**

Telephony

Telephone monitoring (**telephony**) is the most basic type of telehealth. It can be described as remote care delivery or monitoring in which scheduled patient encounters via the telephone occur between a healthcare provider and a patient or caregiver. Some telephone consultations are automated, with alerts sent to the professional for intervention if a patient issues a negative response to a screening question during an automated call. Bhatia et al. (2022) reported that the majority of their study participants "preferred video over phone-only visits because they felt communication was better and more effective with video" (p. 3489).

mHealth

The use of mobile phones, tablets, and personal digital assistants for managing health is a rapidly advancing form of telehealth. There are numerous applications (apps) that target specific health behaviors and illnesses and that provide a platform for management at a distance. One such management technique is a targeted text message to remind patients to perform a certain behavior, such as monitoring their peak flow to manage asthma or to take medications. Other apps are more specific to public health or provider education. Vo et al. (2019) performed a meta-analysis of qualitative studies published on users' perceptions of mHealth apps. "From the patients' point of view, mHealth could facilitate communication with health care providers and other patients, encourage them to be more participative during clinical encounters, and promote the use of coping techniques to manage their illness" (para. 40). Müeller et al. (2022) collected data on mHealth and

digital contact tracing technologies that emerged as a result of the COVID-19 pandemic in four countries (United Kingdom, Canada, Kenya, and Rwanda). "It is evident that a wide variety of mHealth and virtual care tools with parallel functionality are being used in different sectors of health care throughout North America, Europe, and Africa" (p. 5). They concluded that "[t]he staggering international increase in the adoption of mHealth and virtual care interventions facilitates researching and comparing their efficacy, paving the way to incorporating them into everyday health care globally" (p. 6).

Nonclinical Uses of Telehealth Technologies

There are also many nonclinical uses of telehealth technologies. Currently, these applications include distance education, including continuing medical and nursing education, grand rounds, and patient education; administrative uses, including meetings among telehealth networks, supervision, and presentations; and research using the internet and other online sources for information and health data management.

All these telecommunications-assisted activities overcome obstacles of distance and provide access to needed health-related information. Clearly, with telehealth, the range of patient care possibilities broadens significantly.

Telenursing

Where does telenursing (nurses using telehealth) fit into today's healthcare delivery arena? As early as 1988, Skiba referred to **telenursing** as the use of telecommunications and information technology to provide nursing services in health care and to enhance care whenever a physical distance exists between patient and nurse or among any number of nurses. As a clinical field, telenursing is part of telehealth and has many points of contact with other medical and nonmedical applications, such as telediagnosis, teleconsultation, and telemonitoring. Telenurses serve as an integral part of the healthcare delivery team, no matter their location. For example, the National Telenursing Center provides expert consultation and support to remote clinicians as they perform sexual assault forensic examinations and collect and preserve evidence to aid in prosecution of the perpetrator (Mass.gov, n.d.). Read more about this center and the services it provides here: www.mass.gov/info-details/about-the-national-telenursing-center.

Applications of Telenursing in Home Care

Health services or health education and support delivered at a distance to a patient's home using communication devices is defined as home telehealthcare (Kinsella, n.d.). Two key values of telehomecare were also emphasized by Kinsella:

1. Nurses can be more alert to patients' current needs and address these needs in a more timely manner than ever before;
2. Patients who receive telehealth interventions can receive more comprehensive management, leading to more rapid stabilization and, ideally, learn how to become more competent in self-management skills (learning self-management being the most cost effective home health service interaction of all). (para. 4)

Joo (2022) reiterated that home "telehealth with nurses' care services offers broad access to patients and suggests that it may help reduce health disparities" and that telehealth provides "continuous and person-centered care" (p. 810). Weaknesses of nurse-led telehealth identified by Joo were the lack of evidence-based practice guidelines, physical assessments that were limited by monitoring tools, and difficulties with psychological care.

As telehomecare has evolved, this definition has expanded to include a broader arena of delivery. In fact, the definition of *home* has expanded to include anywhere outside of an acute inpatient setting—for example, nursing homes, assisted living facilities, and other living situations beyond the single-family home or apartment. Wherever the home setting may be, people want to be cared for there. Today's burgeoning senior population, in particular, has become quite vocal about this preference, and estimates for preferences of aging in place at home are around 90% (AgingInPlace.org, 2023). Fortuitously, the reach of nurses using telecommunications-ready tools in the home is now remarkably extended. Not only have the settings for home care expanded beyond what was usual (the family home) in the past four decades of home health's formal existence, but the types of services delivered to the home have also become more advanced. The home care industry's newest challenge is to work with sicker patients, many of whom have been discharged from hospitals to home earlier than in the past.

This challenge to extend the range of conventional home care is why telehealth can and must be provided to a wide range of patients, including those who

- are immobilized;
- live in remote or difficult-to-reach places;
- have chronic ailments, such as chronic obstructive pulmonary disease (COPD), diabetes, and congestive heart disease; and
- have debilitating diseases, such as neural degenerative diseases (e.g., Parkinson's disease, Alzheimer's disease, and amyotrophic

lateral sclerosis).

All of these patients may stay at home and be visited and assisted regularly by a nurse via videoconferencing, internet, videophone, or other telecommunications means. These telecommunications-ready tools enable home telenurses to follow through with advanced levels of care as needed.

Still other applications of **home telehealth care** involve the care of patients in immediate postsurgical situations, those needing care of wounds and ostomies, and handicapped individuals needing physical therapy interventions or telerehabilitation. In addition to this extended range of patients who can be served with telehealth, many more patients can be seen when telehealth is used. For example, in conventional **home health care**, depending on the distances of travel involved, one nurse may be able to visit as many as seven patients per day. Using telenursing, however, one nurse can remotely visit, or televisit, 12 to 16 patients in the same amount of time using interactive telehealth. Over the past decade, the efficiencies of telenursing have been well documented, as have the resulting improved patient care outcomes that can be expected by frequent telecontact.

Another outpatient application of telenursing is telephony-based **call centers**, which may be operated by managed care organizations, hospitals, and other health organizations. Some call centers also include telemonitoring services, which allow the patient to stay at home and use different telehealthcare devices to transmit biometric and other medical information back to the call center. Monitoring can be intermittent or continuous. This use of the teletechnology allows clinicians to evaluate patients' status and use the data to make decisions to better manage patients' health conditions.

Many features of call centers' services are comparable to conventional hands-on care in the home. For instance, call centers are typically staffed by RNs who act as case managers or perform patient triage. These professionals can provide information and counseling to patients as part of a disease management program

and to educate them on their disease process. In effect, their goal is to offer appropriate access to care (from nurses at the call centers) and help patients to prevent avoidable emergency room visits and rehospitalizations. An example of this assistance includes a nurse calling (i.e., not waiting for a patient to contact the call center) a recently discharged patient with diabetes on a regularly scheduled basis to evaluate progress at home, activity tolerance, medication compliance, foot care, and diet management. This empowering of patients toward self-management is a very significant and needed part of telenursing.

Home care telenursing can also involve other activities, such as providing customized patient education in dietary or exercise needs, nursing teleconsultations, review of results of medical tests and examinations, and assistance to physicians in the implementation of medical treatment protocols. The work can be wide ranging; for example, some home-based telecardiology programs involve the patient, the family, the physician, and a specialized cardiac monitoring center. A multidisciplinary approach is used along with best practice–defined protocols to manage the patient; improve the patient's quality of life; and reduce healthcare costs, especially hospitalization costs. Nurses play a key role in this network of care.

A relatively new role for advanced practice nurses is that of a tele–intensive care unit (tele-ICU) nurse. These nurses provide remote monitoring, oversight, and expert consultation for patients in rural ICUs by examining real-time data collected at the bedside and communicated to a central station. The tele-ICU nurses use computer programs, algorithms, and clinical decision support tools to look for trends indicating that an intervention is needed and then they alert the bedside nurse of the need, thereby providing an extra set of eyes and an advanced level of expertise. Rincon and Henneman (2018) reported that there are over 300 hospitals using tele-ICU services. A typical caseload for a tele-ICU nurse is 30 to 40 patients because (1) the use of high-tech audio and video and other telecommunications tools allows clinicians to move more efficiently between patients; (2) alerts and clinical decision support tools assist with triage and surveillance; and (3) the primary responsibilities of

the tele-ICU team are to gather information, monitor for adverse events, and ensure compliance with best practices (p. 42). The tele-ICU market is expected to continue to grow in the coming years because of increased demand and a shortage of intensivists (Fact.MR, 2022).

By reviewing all these examples of telenursing practice, one can see that nurses using telenursing can broaden their involvement in the targeted care of their patients. Some sources have predicted that home care will soon become the hub of much patient activity: The home will be where care that is begun in hospitals and other settings will be managed over the very long term and in the most cost-effective healthcare setting. Home care telenurses can expect to play a vital and dynamic role in the changing delivery systems that are likely to be put in place in the coming decades.

Telehealth Patient Populations[1]

Any patient who has a condition that must be monitored is a candidate for home telemonitoring. Patients with chronic illnesses have particularly benefited from ongoing monitoring to prevent acute episodes. Patients who are homebound or who have limited access to transportation are also appropriate candidates for such monitoring. Bhatia et al. (2022) reported that "telemedicine eliminated the time, stress, and cost of commuting and parking at appointments or waiting in clinic rooms and avoided difficulties with stairs or walking distances to reach offices" (p. 3489).

Patients With Chronic Diseases

Given demographics and advances in medical practice, there has been unprecedented growth in the number of patients with chronic diseases. Those patients are at significant risk of having an acute episode when subtle but significant changes in their medical condition occur. The ability to identify these changes in a timely fashion allows for changes in medication, lifestyle, or treatment to occur. Identification of a 3-pound weight gain over 5 days in a patient with CHF, for example, allows for interventions that could prevent an emergency room visit and subsequent hospitalization. The categories of patients with chronic diseases who are most monitored today include those with CHF, COPD, or diabetes and those who require long-term wound care.

These patients, particularly those with higher acuity levels, are at significant risk of having a medical crisis that might necessitate emergency or unplanned acute interventions. Many other patients with chronic diseases are less susceptible to a health crisis but would greatly benefit from home telemonitoring to improve care and reduce costs.

At-Risk Populations

Telemonitoring can be used effectively on patients who are at greater risk for an episode of acute illness. Patients who have a predisposition to disease are at increased risk of medical problems associated with employment, lifestyle, or location, and those patients who have displayed early signs of potentially serious health problems could be placed on preventive monitoring. In such cases, monitoring is used to ensure that interventions are timely and that acute incidents are avoided. Such technology could be part of a healthcare early-warning system and support preventive models of care.

Isolated Patients

Home telemonitoring is effective for patients who cannot physically access healthcare services. The homebound elderly have been among the first to benefit from this technology in conjunction with the home health services they receive. With increasing limits affecting the ability of patients to receive services in the home because of staffing shortages and coverage limitations, telemonitoring technology takes on greater importance in managing homebound patients.

Patients in remote geographic areas have been longtime users of telemedicine interventions. With few rural healthcare facilities being built and access problems becoming more difficult, the use of technology in the home will increase. Even in suburban and rural areas, access is becoming more problematic, requiring greater use of home telemonitoring interventions. A lack of primary care and emergency resources in many urban core areas has prompted many health systems to consider managing certain patients through telemonitoring options and better staging of patient access. Ross (2018) described a home care robot called Rudy:

> *At the average height of a 10-year-old child, Rudy can also provide light in dark areas, call emergency numbers for help, carry objects, set reminders and notify family members or friends on demand. Rudy can work on its own, or it can be controlled by a nurses' aide or family*

> *member from an app. The robot takes the lead and provides care to the older adult, making note of medication usage, response times and more.* (para. 6)

Incarcerated Patients

Telehealth services are used extensively in several states to provide mandated medical services for prison populations. Incarcerated patients are considered a vulnerable population and frequently have numerous chronic diseases (e.g., hepatitis C, HIV, COPD, asthma, diabetes, and hypertension) and mental health issues (especially substance abuse) that require continuous care (Young & Badowski, 2017). Correctional telemedicine programs can be cost effective and promote public safety and more humane care by not having to transport prisoners to healthcare facilities for care (UNC School of Medicine, 2021; Weinstein et al., 2014). As Young and Badowski pointed out,

> *[i]ncarcerated individuals often do not have easy, or any, access to medical professionals with subspecialty training and experience due to the common barriers of geography, limited transportation and cost. . . . For the incarcerated, technology-based solutions must be utilized to improve access to care, connecting patients with providers in a way that removes geographic barriers and the healthcare restrictions of the correctional environment.* (pp. 1–2)

Wurzburg (2021) indicated the need for dedicated spaces in prisons for telehealth consultations to ensure patient privacy. Expect that technology-based solutions will increase in the future to provide effective care to this population.

Hospitalized Patients

Home telemonitoring has proved effective in managing the flow of patients into and out of hospitals and other inpatient facilities. Patients are monitored to determine when they are admitted, predict how long they might stay, and prevent unfunded readmissions. Patients undergoing semi-elective procedures can be better staged

with scheduling options when they are monitored in the home before admission. If deterioration of the patient's condition is observed, a procedure can be accelerated or planned interventions can be changed.

Monitoring can also be used effectively in length-of-stay reduction strategies. Physicians and surgeons are more confident in discharging patients early when they know that vital signs will be monitored and any decline in condition will be noted in a timely fashion. Use of monitoring effectively allows for an extension of step-down models of care into the patient's home. These length-of-stay management strategies have been particularly useful when hospital beds are in short supply.

Unplanned readmissions are a serious patient care and financial management issue for hospitals. The use of monitoring in the home has consistently reduced unplanned and unfunded readmissions by enabling healthcare providers to obtain reliable information on the patient and intervene appropriately to keep the patient at home.

Emergency Response Situations

Telemedicine will likely be a major component of effective patient management in a major disaster; large-scale nuclear or biochemical attack; and as we have experienced in 2020, the outbreak of a highly infectious disease. In such situations, traditional healthcare delivery systems may become overwhelmed, and patients will need to be more effectively triaged and managed by remote providers. Telemedicine applications allow for a dramatic extension of patient management, triaging options, and off-site providers to be involved in care. If an infectious or communicable disease is involved, patient isolation could be accomplished in the home using telemedicine technology.

Concerned Patients and Families

Perhaps the largest potential market for home telemonitoring is patients and families who want to have reliable and objective information that allows for their involvement in healthcare decision-making. At one extreme is a young person who wants to monitor physiological data as part of a personal wellness or fitness program. At the other extreme are families who want information on the status of a terminally ill loved one in another city. In between, there is a wide range of opportunities for individuals and families to obtain information that promotes realistic and meaningful dialogue with healthcare professionals.

Assisted Living and Subacute Patients

In assisted living facilities or subacute care centers, a kiosk can be used to obtain vital signs for large groups of people. Vital signs reports can then be forwarded on a regularly established schedule to physicians and others involved in the patient's care. This approach allows for better individual care management and lends itself to developing intervention strategies and education options to benefit the entire population of a facility. The CMS issued a telehealth tool kit in response to the COVID-19 pandemic. The tool kit detailed the plan for payment for telehealth services and relaxed some of the Health Insurance Portability and Accountability Act (HIPAA) requirements. Two additional requirements are that the provider must use an interactive video and audio platform that permits real-time communication and that a staff member at the facility must manage the technology during the telemedicine visit (CMS, 2020a). Some facilities have even used access to telemonitoring systems as an inducement to attract potential residents.

Employers and Wellness Programs

Health care is a vital concern for employers. They have a direct financial interest in lowering costs and are financial beneficiaries of long-term–illness preventive strategies. If they can monitor their

workers (e.g., offer telehealth options as a wellness program), they will see many benefits for themselves, such as reduced absenteeism and increased productivity. Effective monitoring programs can ultimately lower healthcare costs and associated insurance premiums. Some companies are now exploring the creation of financial incentives for employees who achieve healthcare objectives, such as appropriate weight, reduced blood pressure, and levels of exercise. Monitoring could very well be used as a means of tracking performance in this regard. Friedman (2019) described a comprehensive employee health telemedicine system developed by Tampa General Hospital. The ultraviolet light–sanitized kiosks provide high-definition video and audio visits that allow for general health screening (e.g., height, weight, temperature, pulse, blood pressure, and oxygen saturation) and provide prescription services and self-administered lab kits. "Once the prototype stage for these new kiosks is completed, the hospital says it has plans to deploy them in other venues like airports, colleges, and hotels" (para. 4). The Kaiser Family Foundation (2021) reported that support for telemedicine use by employers increased as a result of the pandemic and that many employers expanded telemedicine coverage for mental health services.

Tools of Home Telehealth

A wide and growing range of telecommunications-ready tools are available for nurses' and patients' use in the home.

Central Stations, Web Servers, and Portals

Central stations, **web servers**, and **portals** are various terms for the technologies presently used as part of multifunctional telehealthcare platforms and application servers. These clinical management software programs receive and display patients' vital signs and other information transmitted from a medical device, including blood pressure, weight, and glucose information. Such

transmission was initially most accomplished over plain old telephone system (POTS) lines; however, network access and wireless communication are more commonly used as technology advances and access improves.

Central stations and web servers are key components of telehealth that can be as minimal as a single-screen display or as comprehensive as software applications that provide various functions, including triaging the data based on medical alerts, which allows clinicians to quickly identify those patients requiring immediate attention. Other features found in these packages allow clinicians to build personal medical records for patients and provide trended patient data and analysis reports to support improved patient outcomes using telehealth. In addition, some of the software packages provide remote programming capabilities that allow the clinician to remotely program the medical device in the patient's home. Such an application can change monitoring report times for patients, individualize alert parameters, set up reminders, and send educational content to a patient.

Peripheral Biometric (Medical) Devices

Peripheral biometric (medical) devices can consist of fully integrated systems, such as a vital signs monitor, or they may be stand-alone telecommunications-ready devices, such as blood pressure cuffs and blood glucose meters. These devices plug directly into a household telephone jack to send data to a central server location or use Bluetooth technology to transmit data.

> *An ever-increasing number of peripheral devices are being introduced to the market. Examples of other peripheral devices seen today in home telehealth include pulse oximeters, international normalized ratio meters (measure prothrombin time), spirometers, peak flow meters, electrocardiogram monitors, and card readers and writers that use smart card technology and enable multiple users to use one device.*

Rose et al. (2022) assessed the reliability of sensors for assessing gait and chair stand function and concluded that "[w]earable sensors

could be used to remotely monitor gait and chair stand function in participant's natural environments at a lower cost, reduced participant and researcher burden, and greater ecological validity overcoming many limitations of lab visits" (p. S19).

Telephones

Telephones are already the most familiar household communications tool used in telehealth care. A telephone device can be augmented with a lighted dial pad, an autodial system, or a louder ringer for easier use by patients who need such augmentation. Telephone systems are still and will continue to be important when there is no internet access in the home.

Video Cameras and Videophones

Video cameras, videophones, and smartphones are readily available consumer items that can be used in telehealth for show-and-tell demonstrations by nurses for patients or to capture wound healing progress, among other applications. Typically, these products operate as a standard telephone or as a video picture telephone, using standard telephone lines to transmit information or interactions. If the patient has a Wi-Fi network, then a smartphone can easily transmit images in this manner.

Currently, the image quality over a POTS is limited by the bandwidth of POTS technology, which favors use of such images for assessment rather than for delivering diagnostic-quality images. These imaging capabilities will improve as integrated services digital network lines become more widely available in the home environment. Typically, medical centers and hospitals have access to larger bandwidth capabilities for image transmission and viewing, thus ensuring high-quality diagnostic images and point-to-point consultations in hospital-based or medical center–based settings.

Personal Emergency Response Systems

Personal emergency response systems are signaling devices worn as a pendant or otherwise made easily accessible to patients to ensure their safety and enable them to quickly access emergency care when needed, usually in case of a fall. A preset telephone number is alerted by the patient pushing a button on the pendant; upon this signal, predesignated emergency help is dispatched. Many newer sensor options for tracking patients at home are being incorporated into multifunctioning personal emergency response system devices, such as alerting a central call center to water flooding or smoke in a patient's home. The next subsection provides details on these sensors and monitors.

Sensor and Activity-Monitoring Systems

Sensor and activity-monitoring systems can track activities of daily living of seniors and other at-risk individuals in their place of residence. These sensors and monitoring systems can provide insight into behavior changes that might signal changes or deterioration of health status. Such technologies consist of wireless motion sensors that are strategically placed around the residence and can detect motion on a 24-hour basis.

Data from these sensors are wirelessly sent to a receiver and base station, which periodically transmit the information to a centralized server. Sophisticated algorithms analyze and compile data on each individual's normal patterns of behavior, including bathroom usage; sleep disturbance; meal preparation; medication interaction; and general levels of activity, including fall detection. Deviations from these norms can be important warning signs of emerging health problems, and the alerts provided can enable caregivers to intervene early (Breaux, 2023).

In addition to widely used fire, security, and home gas detectors, other sensors can monitor appliances to detect whether a household appliance is turned on or off and, with some devices, actually switch the appliance on and off for the resident. Typical applications for affixing programmable sensors can include lamps, television sets,

irons, and kitchen stoves. Such sensors might be very valuable for ensuring the safety of elderly, forgetful persons who live alone. One excellent example of today's sensor use for assistance with the elderly are sensors placed in or on stovetops to alert users when they are standing too close to the equipment or the kettle or pot has boiled over. Benefits realized from these technologies include enabling people to live independently with an improved quality of life. They can also provide peace of mind for other family members living at a distance. Smart home technologies have continued to evolve and become more sophisticated and reliable (Hipp, 2023; Matte, 2018), thus providing benefits, such as safety and security, and supporting independent living and providing peace of mind.

Medication Management Devices

Medication management devices address a well-recognized major problem in health care, medication management and compliance. The failure of patients to take medications as prescribed has become a national problem in health care today. This noncompliance can have devastating consequences, particularly for those patients living with chronic illnesses. Lloyd et al. (2019) reported that medication nonadherence ranged from 23% for heart failure to as high as 38% for managing hyperlipidemia. Annual costs of nonadherence, ranging in the billions of dollars, are based on emergency department visits and inpatient hospitalizations as a result of poor disease management.

To address some of these very pressing problems, a host of telecommunications-ready medication devices have become available, and many more are in development. Devices are as simple as a watch that reminds a person to take medications and pill organizers with audible reminders, and some can even be programmed to dispense prefilled containers with medications and alert a patient or caregiver of a missed dose. Furthermore, some of these medication tools send data from the device back to a central server so that patients' medication compliance can be tracked. These

telecommunications-ready devices can organize, manage, dispense, or remind, and they will play an increasingly important role in helping people live independently and manage their disease processes through medication compliance. For more information on these devices, see Chapter 15, *Informatics Tools to Promote Patient Safety, Quality Outcomes, and Interdisciplinary Collaboration.*

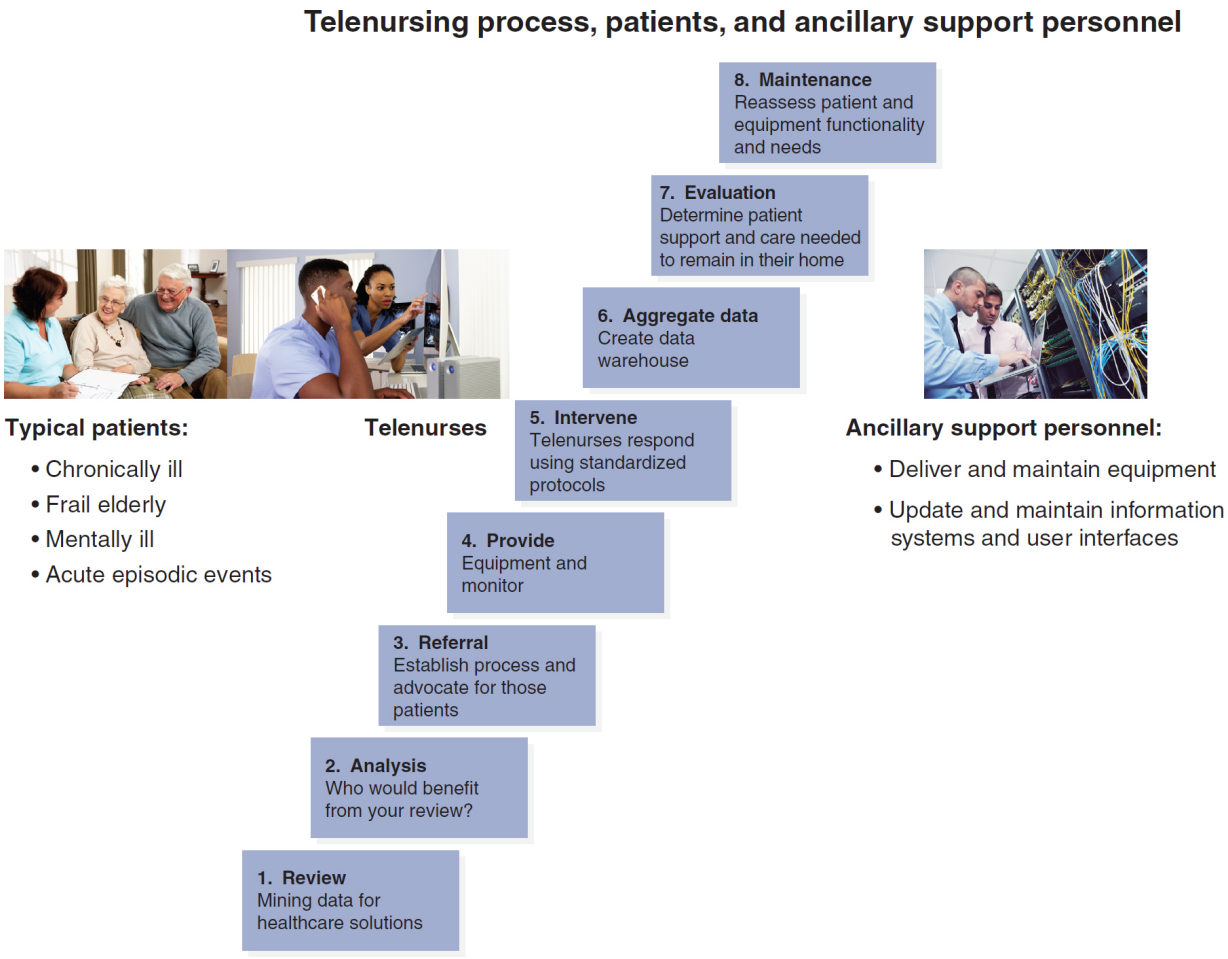
Special Needs Telecommunications-Ready Devices

Special needs telecommunications-ready devices can include preprogrammed, multifunctional infusion pumps for meeting a range of infusion needs, including medications for pain management and other infusion delivery needs, such as hydration and nutrition, peak flow meters, and electrocardiogram monitors. Many such tools are in development to meet the more demanding and challenging needs of today's at-home patients. The common goal of these tools is to increase communications between nurse and patient and to increase the nurse's knowledge of the patient's status in a timely manner. A relatively new device approved for home use by the U.S. Food and Drug Administration (FDA) is Tyto, described by McDaniel et al. (2019) as follows:

> *The Tyto device (TytoCare Ltd., Israel) is a novel examination system that includes a built-in examination camera, an infrared thermometer, a wireless communication unit, a lithium ion battery, and a touch screen. The system also incorporates a digital stethoscope, a digital otoscope, and a tongue depressor. The Tyto platform enables the capacity for live video or store and forward applications, and users can be directed by voice or on-screen instructions to obtain images and sounds to comport with the standard of care by enabling a remote physical examination.* (p. 2)

Read more about this device and see illustrations provided on the product's web page at www.tytocare.com.

Figure 18-3 illustrates the process for managing home telehealth.



Elderly patients at a consultation: © Monkey Business Images/Shutterstock; telenurses looking at computer screen: © Rocketclips, Inc./Shutterstock; computer technicians: © dotshock/Shutterstock.

Figure 18-3 Managing Home Telehealth

Description

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1 This section is adapted from Prial and Hoss (2009).

Home Telehealth Software[2]

As important as the gathering of data is the organizing of information to support decision-making by clinical professionals. The telehealth software that supports home telehealth programs has become much more sophisticated in recent years and now allows for greater numbers of patients to be better managed by a single clinician. Areas of significant improvement in software include trending, triage, communications protocols, access, and sharing.

Trending

One of the key advantages of home telemonitoring is the creation of a digital health record that allows information to be recorded over time. If patients take their weight and blood pressure daily, most software will graphically display these data over time so that subtle trends can be observed. This type of trend data is much more useful in identifying emerging or developing conditions than is snapshot data, which are collected every 6 to 8 weeks at a physician's office. Trend information can also be developed for groups of patients or populations, which allows for population-based analyses of interventions. For example, one might gather trend information on patients with COPD, patients of a particular physician, or all patients receiving a certain medication.

Triage

Most home telemonitoring systems set an acceptable range of values for individual patients when they are enrolled in the monitoring program. For example, if oxygen saturation, blood pressure, or weight values go above or below predetermined amounts, then the software alerts the appropriate party. More sophisticated software looks at readings from multiple pieces of equipment on a single

patient and can give higher priority to patients at risk of an acute episode. These systems help clinicians better organize their work and arrange for appropriate interventions.

Communications

Advanced telemonitoring software utilizes sophisticated electronic notification protocols. Often, when information will be communicated and to whom it is sent are predetermined. Sophisticated protocols can be developed related to both routine and alert information, thereby more effectively organizing communications with physicians, nurses, and caregivers. Some systems also have the capacity to communicate back to the patient or seek additional information under predetermined circumstances.

Data Access and Information Sharing

Many telemonitoring systems house information in web-based formats. This format allows for easy access to the data from any location that has access to the internet. Multiple parties can simultaneously share and view data. Data can also be conveniently transmitted to other clinicians and are updated almost immediately when new values are received. Web-based records are fully HIPAA compliant when appropriate protections and controls are in place.

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2 This section is adapted from Prial and Hoss (2009).

Home Telehealth Practice and Protocols

The tools of telehealth described previously are devices that enable remote care delivery, enhance patient care, and improve outcomes. It is important to note that the data received from these tools are useless without some type of clinical oversight. Such tools do not replace the nurse but rather give the nurse the ability to make more informed clinical decisions based on reliable data and a comprehensive picture of the patient's status. In home care, they also direct the clinical resources to patients based on need. The resulting patient-centered approach to care delivers improved patient outcomes and clinical efficiencies.

Home telehealth is indeed a practice, albeit one that represents a change in the current clinical model of practice for home care. Use of the telehealth tools is integrated into the practice to improve patient outcomes. As with any tool, however, the effectiveness is directly proportional to the appropriateness of the tool's application and use. Home telehealth programs differ depending on the type of technology used and the foci of the telehealth programs. However, every program should have telehealth use criteria established, including provisions for informed consent and assessment of the appropriateness of telehealth use for specific situations. The ATA regularly develops and issues practice guidelines, which can be accessed at its website: www.americantelemed.org/resource_categories/practice-guidelines. Note that the ATA requires you to register with them to access the guidelines.

Other professional organizations, such as the American Nurses Association (ANA), the AACN, and the American Academy of Ambulatory Care Nursing (AAACN), also provide telehealth practice guidelines. Patient criteria for telehealth should be governed by established inclusion and exclusion guidelines that detail who is eligible and appropriate for each type of technology. Other criteria include establishing policies and procedures that address patient

enrollment, education, and equipment setup; patient and caregiver and home assessment; **patient informed consent**; and privacy and confidentiality rights. In addition, a clinical plan of care that is specific to patient needs should be developed. Telehealth pathways and protocols ensure more focused work with patients and allow for targeted interventions.

CASE STUDY: HOME TELEMONITORING OF MULTIPLE ILLNESSES

The patient is a 71-year-old male who has stage 4 cardiomyopathy/pulmonary hypertension, atrial fibrillation, COPD, and type 2 diabetes mellitus. He has been an active patient with a home healthcare agency for several years, with an admitting diagnosis of CHF.

Initially, the patient was seen three times a week by an RN for CHF assessment and management. The patient's history included frequent hospitalizations for exacerbation of CHF and uncontrolled atrial fibrillation. He experienced a total of four hospitalizations in the year before placement of a telemonitoring system in his home, after about 6 months of receiving conventional home care.

Ever since the patient was placed on a telemonitoring system for daily tracking more than 8 months ago, he has not been hospitalized. The telemonitoring interactions with his nurse have made him very conscious of the role that his medications, diet, and fluid restrictions play in his overall health status.

In addition, the telemonitor has proved its benefits to local physicians. The patient's family physician, cardiologist, and pulmonologist were able to provide better care for the patient by examining the tabular and graphical trends that were elicited from the daily vital signs monitor. This information aided in the titration and addition of the various medications needed to control the patient's CHF and atrial fibrillation. The physicians were able to ascertain the response to the medication adjustments and other treatment modalities, such as oxygen titration. At the start of care, the patient's weight was 196 pounds; it is now at a stable 187 pounds, with the symptoms more controlled than they have ever been.

The patient's nurses, meanwhile, have peace of mind knowing they can keep an eye on their patient daily while making additional visits as needed, with the documentation being provided by the system to justify the additional

nursing visit. This tool can also be incorporated into the nurses' care plan, enabling a higher standard of care to the patient.

At present, the patient is being case managed by nursing staff visits that occur once per month. He now enjoys a newfound peace of mind and security and an improved state of health, something this patient had not experienced in more than a year.

Clearly, by using a protocol for patients who regularly use telehealth equipment for tracking their status, nurses receive a good deal more targeted information than can possibly be obtained during scheduled in-person visits. As a result, the use of telehealth tools, together with clinical oversight and practice, makes possible more efficient and effective clinical management by allowing the patient's needs to drive the care. As home telehealth protocols are used more extensively, the improved clinical and operational efficiencies may ultimately affect the home care agency's bottom line.

It is important that this clinically driven, as-needed approach to care services is not misunderstood as providing less care. In the previous case study, a proactive, patient-centered approach enabled a home healthcare agency to identify early exacerbations in a patient's condition and take appropriate action.

Legal, Ethical, and Regulatory Issues

Telehealth is affected by certain legal, ethical, and regulatory issues of which nurses should be aware. Prior to the COVID-19 pandemic, interstate practice of telenursing, for example, required nurses to be licensed to practice in all the states in which they provided telehealth services and directly interacted with patients. This was particularly important when nurses worked for health systems that are located near state borders and draw patients from both states. A possible solution is the development of the federally sponsored physician Interstate Medical Licensure Compact and Nurse Licensure Compact (NLC) to facilitate portability of licensure across state lines. However, this federal initiative has met opposition from some states that are unwilling to share licensing authority. Gaines (2023) reported that the original NLC was updated in 2018 to the Enhanced Nursing Licensure Compact (eNLC). The eNLC requires criminal background checks and fingerprinting. Currently, 40 states have enacted eNLC licensure, and 4 states have legislation pending. Follow these developments at your state licensing boards. The Center for Connected Health Policy provides an interactive map of current and pending state laws and reimbursement policies at www.cchpca.org/telehealth-policy/current-state-laws-and-reimbursement-policies.

Some evidence exists that these regulations are slowly changing, so it is important for all licensed professionals to be aware of legislation governing specifically their practice. For example, during the COVID-19 pandemic, some laws and regulations related to telehealth practice were temporarily suspended. Telehealth laws and regulations are likely to change again as a result of the end of the public health emergency declaration. Shachar et al. (2020) indicated that "[t]o maintain the impetus for change and the momentum for telehealth services that have resulted from the COVID-19 pandemic, the US cannot revert to prepandemic telehealth regulations. Neither can the US simply adopt the recent changes, because they lack

nuance to support clinicians while ensuring safety and privacy for patients: a third regulatory path is needed" (p. 2376). Follow these developments at the official U.S. government website: https://telehealth.hhs.gov/licensure/getting-started-licensure.

Patient confidentiality and the privacy and safety of clinical data must be given special consideration. Informed consent releases to receive telehealth services are a critical first step and recommended by the Center for Connected Health Policy (n.d.). A typical informed consent for telehealth is a written document that describes what the patient can expect and the security measures that are in place to protect privacy. Informed consent policies for telehealth may vary by state (Center for Connected Health Policy, n.d.). You will also find important informed consent information at https://telehealth.hhs.gov/providers/preparing-patients-for-telehealth/obtaining-informed-consent. Pointed efforts must be continually undertaken by the nurses' agencies to upgrade their information systems to ensure that a high level of data security is provided at all times. Telehealth providers must adhere to all data privacy and confidentiality guidelines and remain vigilant to ensure that all involved parties, including the technical staff support assistants, have appropriate training in privacy and confidentiality issues.

The Patient's Role in Telehealth

The range and sophistication of home telehealth tools are expanding consistently, and a concern of nurses when choosing appropriate tools for their patients is whether their patients will use these devices. For example, to assist in wound care tracking, elderly patients may find the monitoring technology and video cameras that are placed in their homes to be a daunting introduction to home health care. To assuage the possible discomfort, these and other such tools have undergone many iterations so that they are easier to use and patients' ability to turn them on and off is ensured. When patients are scheduled for a televisit, these devices can be turned on and used. Patients' use of these devices is critical so that the necessary information about them can be gathered and transmitted and telenurses can attend to their needs. Consideration of technology usability issues when initiating telehealth applications with elders, who may have sensory, cognitive, and motor disabilities, should be paramount. The use of the technology should not be stress producing for the patient or the family.

Telehealth Research

Telehealth research focuses primarily on clinical outcomes, such as effectiveness of telehealth compared to usual care, cost-effectiveness of telehealth intervention, and patient and family satisfaction.

To follow the progress in telehealth research, bookmark the sites provided in **Box 18-1**.

BOX 18-1 TELEHEALTH RESEARCH AND INFORMATION CENTERS

- Center for Telehealth and e-Health Law: www.ctel.org
- International Society for Telemedicine and eHealth: www.isfteh.org
- National Consortium of Telehealth Resource Centers: www.telehealthresourcecenter.org
- Telehealth Research Centers of Excellence (TRACE): https://healthcaredelivery.cancer.gov/telehealth/trace.html
- Rural Telehealth Research Center: www.ruralhealthresearch.org/centers/telehealth
- Telehealth.HHS.gov: https://telehealth.hhs.gov/for-researchers
- Virginia Telehealth Network: www.ehealthvirginia.org

Evolving Telehealth Models

Previous telehealthcare deliveries were largely provider initiated; however, we are beginning to see that consumers will drive the way health care is delivered in the future. Consider that tomorrow's healthcare facility might have no walls. The evolving roles of the internet, electronic and personal health records, mHealth, health information exchanges, and telehealth will support a more integrated healthcare model. This convergence of trends and solutions will continue to expand with the introduction of new business practice models, such as retail clinics and direct-to-consumer telehealth services.

Retail clinics, such as CVS's MinuteClinics, began to emerge in 2001 and numbered 2,800 in 2017, and are likely to continue to grow (Advisory Board, 2019). These clinics focus on prevention services, such as vaccines; treatment of minor injuries, minor illnesses, and aches and pains; and health monitoring and medication management services for chronic illnesses. The clinics offer affordable, accessible, walk-in and after-hours care and are helping to fill the primary care gap created by the Affordable Care Act. Adding telehealth services is allowing these clinics to expand their services. Wicklund (2019) reported that "Walgreens, CVS Health, Rite Aid, Publix, Target and Walmart are either teaming up with local health systems, partnering with telehealth providers and migrating healthcare services to an mHealth platform or looking to develop clinics that facilitate care management, rather than one-off visits" (para. 4). As a result of the COVID-19 pandemic, it is likely that these retail clinic telehealth services will grow even more rapidly, especially because of the expanded payments allowed by CMS in response to the pandemic. As Dacey (2020) pointed out, "[a]nd once we are through the healthcare crisis facing us all CMS will face another challenge, perhaps more difficult in a way. How are they going to get the telehealth genie back in the bottle?" (para. 12).

Several telehealth organizations also provide downloadable telehealth apps for consumers to consult directly with board-certified doctors via smartphones, tablets, and computers. For more information, please visit https://business.amwell.com, www.doctorondemand.com, or www.teladoc.com as examples of online consultation. New telehealth companies are entering the market nearly every day, with a predicted growth of 22.5% in the next 5 years (Cision PR Newswire, 2020).

Several new trends include more robust mobile devices that connect with each other (Internet of Things) to provide real-time data on patients' fitness and exercise and health data, such as electrocardiograms, heart rates, and blood sugars, to their physicians' offices. The difficulty with these devices is ensuring security of data transmissions as well as the possibility of overwhelming physicians with data (TechTarget, 2017). As one physician mused, "While still recovering from this inescapable occupational hazard of the new digital documentation, a technological surge of broadband-enabled technology has inundated us. These have surfaced as ingestible, wearable and embeddable based on the route of placement. Are we physicians labeling the data provided by them as patient health information (PHI)?" (Thingalaya, 2018, para. 2). Even though these wearables are becoming more sophisticated, they are still subject to artifacts and measurement inaccuracies. They can, however, alert patients of potential issues and prompt them to seek medical consultation.

The Telemed Tablet is an FDA-approved device that provides access to a pool of specialists for consultation in rural clinics, at the bedside in hospitals, or in emergency rooms. It also allows on-call providers to consult remotely. More information about this product can be found at https://static.americanwell.com/app/uploads/2016/03/Telemed-Tablet-Brochure.pdf.

TytoCare provides an at-home reusable diagnostic kit (one-time fee) that enables high-quality video and audio to be sent to a consulting physician (billed each visit): www.tytocare.com/home-smart-clinic.

We expect ever-more innovative and sophisticated products to arrive on the market in the coming years.

Parting Thoughts for the Future

Telehealth is here to stay and will become increasingly important in the future. The barriers to telehealth related to broadband access must be addressed soon.

The care continuum will need to be supported by a clinical and caregiver structure that uses the data collected from patients to make better and more informed healthcare decisions. Health parameter data could be used by the end user for personal direct-care decision-making or by a member of the healthcare community to determine appropriate healthcare interventions.

The technology of today will be different from the technology of tomorrow as access to broadband communications systems, acceptance of technology, and mobility and data transfer continue to evolve. As a result of emerging needs, many companies will enter the market and offer a wide range of information technology tools, ranging from embedded and worn sensors to remote monitoring devices. User interfaces will become increasingly sophisticated and more patient centric.

Clearly, by making key information readily accessible, solutions across all areas will facilitate collaboration in care delivery and health information. Products that integrate into consumers' and patients' everyday lives to improve their quality of life will continue to emerge. Telehealth and telenursing will play an important role in improving quality of life and care for the patients served.

Foremost, nurses must be open to change and willing to embrace ever-evolving practice models. Tools should always be used to improve care delivery models to make more targeted contact with and about patients. In an ideal world, there would be seamless integration of clinical data systems and robust data exchange to provide quality care for patients no matter their location.

Summary

Telehealth is a rapidly developing mode of health service delivery, in which nurses can expect to play a significant role. The most promising area of concentration for nurses is in home telehealth care, an area that is expected to provide extensive care to the burgeoning number of American elderly persons living with challenging chronic diseases and conditions. Many telecommunications-ready tools to assist nurses in delivering this care are currently available, and their effectiveness in maintaining or improving patients' health outcomes is well documented. Today's nurses are providing telehealth services to typical home care patients (i.e., elderly patients and patients needing regular and targeted care) and operating effectively as telenurses. The practice of telehealth will provide opportunities for telenurses to become key players in care management across the healthcare continuum.

THOUGHT-PROVOKING QUESTIONS

1. Will the increased use of telehealth technology tools be viewed as dehumanizing patient care, or will it be viewed as a means to promote more contact with healthcare providers and as new ways for people to stay connected (e.g., online disease support groups), thereby creating better long-term disease management and patient satisfaction?
2. Which types of resistance to new technologies might be evident among patients, caregivers, and nurses? Which evidence and strategies might help to diminish these resistances?
3. As telehealth technology advances toward seamless data access, regardless of distance or health system, how can patient privacy rights and the confidentiality of personal medical data be protected?
4. Consider a recent patient care scenario, and describe how it could have been managed at a distance.
    - Which training would be needed?
    - Which equipment would be used?

- How would the patient and their family respond to home telemonitoring?

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SECTION V
Education Applications of Nursing Informatics

Chapter 19 Nursing Informatics and Nursing Education

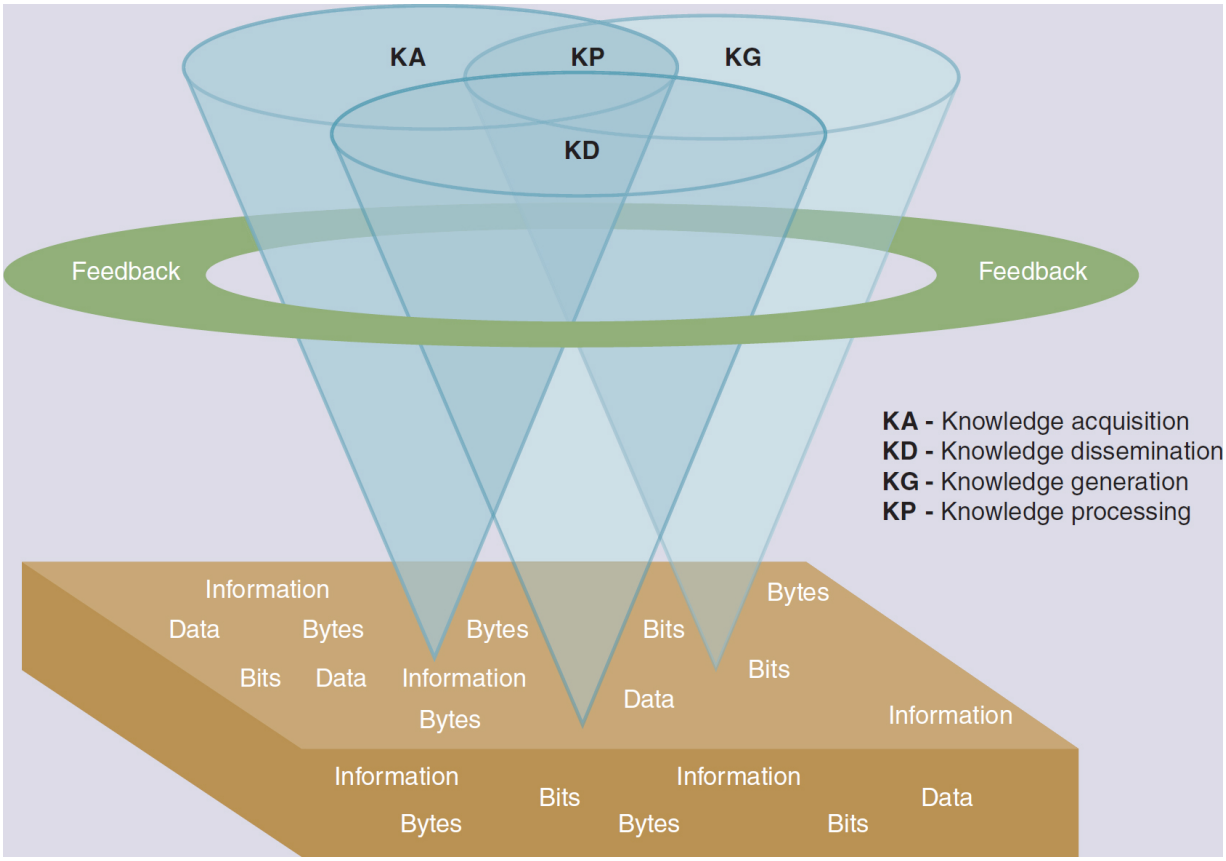
Chapter 20 Simulation, Game Mechanics, Virtual Worlds, and the Realities in Nursing Education

Nursing informatics (NI) provides more tools and capabilities than can be imagined. Just as NI has changed the way nursing is administered and practiced, it has dramatically affected nursing education practices.

Nursing education is evolving with the increased integration of NI and other technology tools to promote learning. The tools that are available must be used prudently by reflecting on and applying knowledge of teaching styles, learning styles, and other pedagogical concerns. As informatics capabilities continue to expand, a phenomenal amount of potential for virtual reality–embedded education looms on the horizon. Once the purview of gamers and geeks, virtual reality has exploded onto the academic scene. The use of virtual reality has the potential to cross over into the curriculum, the university, and even the learning systems themselves. Many university departments will experiment with virtual reality in hopes of staying current and appealing to their young and demanding "Generation Next" constituency. However, much of society loves the feel of books too much to dismiss them as archaic. There is room for both books and technology in education. Students, educators, and administrators will ultimately return to a modified form of face-to-face classroom teaching, even with the availability of newer and more adventuresome teaching technologies. Furthermore, after fast, high-burn technologies (technologies that come on the market with lots of hype but flame out quickly) stop flooding the marketplace and big business provides opportunities for proprietary online

universities, modified traditions will take their place, creating new spaces for nontraditional students and members of the Net Generation and Generation Z, with both being anxious for technology use in the classroom for very different reasons. Artificial intelligence (AI) has exploded onto the academic scene, and this disruption must be addressed.

The material in this book is placed within the context of the Foundation of Knowledge model (**Figure V-1**) to meet the needs of healthcare delivery systems, organizations, patients, and nurses. Nursing education promotes scholarship and evidence-based teaching and learning. Through the sound integration of information management and technology tools, teaching and learning strategies promote the social and intellectual growth of the learner. As teachers' and learners' quest for knowledge, the need for the pursuit of lifelong learning is instilled. Teachers and learners involved in the process of education are also involved with all levels of the model. Typically, they acquire and process data and information and generate and disseminate knowledge within the frame of reference of their educational institution. Their knowledge generation remains on a limited individual, course, or school basis unless they become involved with developing publications and educational research that inform others in the nursing profession.



Designed by Alicia Mastrian

Figure V-1 Foundation of Knowledge Model

Description

The reader of this section is challenged to ask the following questions: (1) How can I apply the knowledge I gain from my education to benefit my patients and enhance my practice? (2) How can I help my colleagues, patients, and fellow students understand and use the current technologies to promote learning? (3) How can I use my wisdom to help create the theories, tools, and knowledge of the future?



CHAPTER 19

Nursing Informatics and Nursing Education

OBJECTIVES

1. Describe nursing education in relation to the Foundation of Knowledge model.
2. Explore knowledge acquisition and sharing.
3. Assess technology tools and delivery modalities used in nursing education and continuing education.
4. Compare and contrast knowledge assessment methods.

KEY TERMS

- advocate
- artificial intelligence (AI)
- asynchronous
- audiopod
- blended
- Blockcerts
- blockchain
- blog
- case scenario
- collaboration
- computer based
- continuing education (CE)
- copyright

- distance education
- distributed ledger technology (DLT)
- e-learning
- electronic mailing list
- email
- evidence
- face-to-face
- fair use
- Foundation of Knowledge model
- Generation Z (Gen Z)
- hybrid
- hypertext
- information literacy
- instant message (IM)
- iPod
- learning management system (LMS)
- MP3 aggregator
- MP4
- multimedia
- Net Generation
- online chat
- podcast
- portal
- portfolio
- problem based
- professional networking
- real time
- really simple syndication (RSS)
- reflective commentary
- resource description framework (RDF)
- role-playing
- simulation
- smartphone
- tutorial
- videopod

- virtual reality (VR)
- web based
- webcast
- web enhanced
- webinar
- web publishing
- wiki

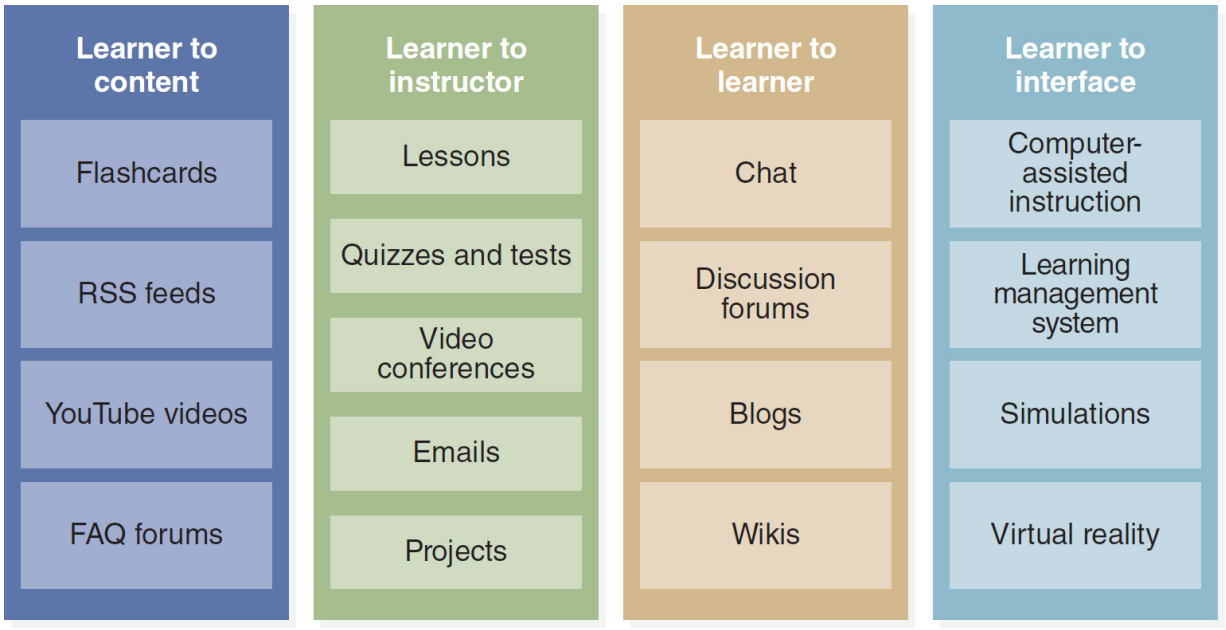
Introduction: Nursing Education and the Foundation of Knowledge Model

Nursing informatics facilitates the integration of information, data, and knowledge to support nurses, patients, and other providers in their particular settings and decision-making roles. The **Foundation of Knowledge model** specifically prompts nurses to extend their theoretical and metaphorical knowledge into practical, holistic determinations based on a variety of factors and contexts. Because competencies in informatics include but are not limited to **information literacy**, computer literacy, and the ability to use strategies and system applications to manage data, knowledge, and information, the ability of nursing students to use computer-mediated communication skills is essential to their success in the nursing field and as a means to improve patient safety.

The COVID-19 pandemic caused an immediate rise of telecommunications and virtual technology use in health care. At the same time, education programs were also increasing their use of virtual or online teaching strategies to meet the needs of their learners, and nursing was no exception. Now, going far beyond the simple applications of word processing software or spreadsheets, technology applications have evolved greatly, taking advantage of modern capabilities to provide nursing and related healthcare students with simulations, complex multimedia, virtual reality–assisted clinical scenarios, and a host of information- and literature-gathering internet tools.

Knowledge Acquisition and Sharing

The COVID-19 pandemic triggered a paradigm shift with the shutdowns causing the loss of clinical access and face-to-face meetings. Those who only wanted to test the waters of virtual teaching and learning prior to the pandemic were now diving in to help their students continue their educational programs. Web-enhanced courses were developed that included **online chats**, forum discussions, instant messaging, blogging, and use of **email**, all of which ask the student to engage, digest, use, and disseminate information in new ways (**Figure 19-1**). In addition, mannequin-based or virtual simulations replaced 25% to 50% of some clinical experiences. How nursing students learned and were career readied had changed. Karim (2021) reported that "[p]rior to the pandemic, nursing students were required to spend at least 75% of their clinical time providing direct care to patients in hospitals" (para. 12). Many Boards of Registered Nursing reviewed their regulations and permitted 25% to 50% of the clinical hours to be completed using simulated experiences.



Data from: Juliano, R. (2014). *Best practices guide to converting face to face courses to a distance learning format: Educational technology.* www.manula.com/manuals/rachael-juliano/best-practices-guide-to-converting-face-to-face-courses-to-a-distance-learning-format/1/en/topic/educational-technology.

Figure 19-1 Types of Interactions in Web-Based Courses

Description

Evolution of Learning Management Systems

Twenty-first-century nursing informatics emphasizes technology usability, functionality, and accessibility in education and practice. Consequently, the need to learn nursing skills presented endless potential for software development. Recall that software comprises the instructions that direct a computer's hardware to work, whereas hardware consists of physical computer components, such as a mouse, keyboard, and monitor. Software essentially translates commands into computer language to allow the hardware to perform its functions. Applications software refers to the various programs individuals use to communicate with others, work, play games, or watch multimedia on a computer.

When evaluating software or hardware for purchase, careful assessment of the products and services will help an educator, administrator, or student make the best choices. The most important thing when evaluating software is to understand how well the software's functionality matches the learning goals and objectives. Although many programs are available for assisting a nurse educator who is evaluating software for particular learning purposes, the main criteria are content (Is the information accurate? Is it relevant?), format (How is information visually presented? Is it in frames? Does it come with graphics?), documentation style (What is the tone? Is it scholarly and applicable?), and strategies (Is the software useful for all students, including students with disabilities and remedial and accelerated students?) (Edwards & Drury, 2000). In addition, consider diversity, equity, and inclusion (DEI).

Hardware decisions depend on the way a computer system will be used in addition to considerations related to cost, ease of use, and durability. Systems purchased for personal use may differ dramatically from those purchased for online learning, virtual simulation, or smart classrooms. Remember that you must always consider the level of security that is needed. Because the technology inherent to workstations, servers, and computers, in general, tends

to change rapidly, discussing large-system decisions with an information technology expert is likely to yield a better-informed decision. Other hardware considerations arise from the use of virtual simulation, including the realities and, specifically, virtual reality (VR). What type of head mounted-display (HMD) and controllers will be needed, and if entering the VR environment in non-VR, does this affect the type of computer the learner will need? Education innovators realized the need for additional functionality. Integrated learning systems have evolved from tracking, content management, and more individualized instruction or primarily the administration of the course and content, providing convenience for instructors and learners. The learners typically had only one **learning management system (LMS)** to learn. The LMS was used throughout the program, and the faculty and learners became proficient in its use. The next evolutions that are still in progress are the transition to a learner-centered approach and the integration of adaptive learning. Learning should be tailored to the learner, thus allowing them to have control over their learning, such as how they engage with the content and the pacing of learning. This means that the content must be available in a variety of formats to meet the learning style of each learner as well as providing teacher support and additional content delivery methods for clarity if they do not reach mastery. The LMS with integrated adaptive learning will not only track mastery but also be able to help the student achieve it. The faculty member must be able to offer any necessary support to each learner while monitoring the progress and needs of all the students in the course or learning episode.

Delivery Modalities

Nursing educators are discovering that today's learners may not always respond in the same ways that the educators did during their own tenure as learners. Technology-savvy learners from the millennial age demand instant information delivered in an entertaining fashion, an expectation built on extensive exposure to email, text messaging, online chatting, and the internet (Ridley, 2007). In addition, many nursing departments are facing an increase in student enrollment and a corresponding growth in faculty. Although new nursing faculty members bring significant clinical experience to their academic positions, also apparent for some is an underlying tension and unfamiliarity with technological advances, outcomes-based accreditation initiatives, and teaching itself. Schools of nursing are scrambling to provide professional development for busy nursing faculty members and introduce them to best practices in teaching (Shaffer et al., 2006).

Learning is a multispatial function, and in the age of technology innovation, instructional delivery can inhabit many forms in both physical and virtual spaces. Spaces in academia are no longer defined by a class or its content but instead by the learning the class is trying to promote. To this end, learning spaces should support multiple modes of learning and delivery, including reflection, discussion, and experience, and facilitate face-to-face and online interaction within and beyond classrooms. Truly innovative delivery must support the learning activities whether in face-to-face classroom interaction, online engagement, virtual simulation, the realities, or a blended hybrid of technology and traditional classroom teaching.

Face-to-Face Delivery

Ridley (2007) suggested that although it is the most widely used teaching method among nurse educators, traditional **face-to-face**

lecture yields only a 5% information retention rate over a 24-hour period, a rate that compares unfavorably with demonstration (30%), discussion groups (50%), practice activities (75%), and peer teaching (90%) (as cited in Sousa, 1995).

In addition, the inability of physical space to keep pace with the evolution of learning models inhibits the benefits gained from face-to-face interaction between teacher and student. For example, collaborative learning grinds to a halt when class is held in a room with chairs bolted to the floor, facing a lectern (Oblinger, 2005); this kind of spatial arrangement prohibits a sense of classroom community by inhibiting easy peer interaction, reducing students' ability to see one another, and concentrating all attention on the professor.

Conversely, in a collaborative learning environment, the professor guides conversation and sets up discussion, acting less as the classroom authority and more as a facilitator, helping students maintain focus, gently guiding discussion, and ultimately empowering students to push knowledge boundaries in a safe and secure atmosphere of peer support. This inductive, epistemological approach promotes active, critical thinking skills and assists students in learning not just facts but also how to learn. As future healthcare professionals determined to rely on quantification and rationale, nursing students will benefit from face-to-face classroom interaction that hones their ability to manufacture new personal truths through interaction with people and ideas in ways that cannot always be measured and counted.

Ridley (2007) suggested that such interactive, cooperative learning strategies might include gaming, **role-playing**, and **problem-based** learning. Because games are nonthreatening and fun, they promote critical thinking and teamwork by pushing students to work together in groups to find answers and achieve success. Role-playing is similar in that it allows students to try on real-life scenarios by filling either scripted or ad-libbed roles (e.g., doctor, nurse, patient, or clinician) without the fear or pressure of putting another's life at risk while trying to determine the best course of action or find a solution for a fictitious patient's health issue.

Problem-based learning, a well-accepted form of interactive learning, takes assignments out of a contextual vacuum and applies real-life scenarios to problems or challenges. Students work in groups to solve the dilemma presented by real patient cases and build on prior knowledge, using higher-level thinking skills and progressive inquiry to resolve the problem (Ridley, 2007). This process enhances the student's critical skills for acquiring and maintaining knowledge in practice.

Online Delivery

E-learning, online learning, and **web-based** education have caused a significant shift in learner–teacher relationships in nursing education. According to Oblinger (2005), not only are learning spaces no longer physical or formal, especially on campuses with wireless capabilities, but nursing students also expect to make use of wide ranges of cutting-edge technology during their academic tenure, exchanging the traditional "sage on the stage" for a technologically savvy "guide on the side" (Leasure et al., 2000) who gives up the role of gatekeeper and instead promotes and facilitates dialogue as central to teaching and learning (Aquino-Russell et al., 2007).

Learner centered and no longer limited to the domain of the classroom, laboratory, or even a patient's bedside, online learning allows educators to translate theory into practice by creating a virtual classroom space that promotes **collaboration**, engagement, discussion, and analysis. Studies show that web-based courses not only continue to gain in popularity but also enhance learning in ways that encourage learners to share personal experiences and support. Researchers cite many factors that make online learning laudable, with accessibility and convenience being two of the most frequently cited issues (Aquino-Russell et al., 2007).

The **asynchronous** and time-independent elements of web-based courses respond to the huge need for flexible class times among today's growing population of nontraditional learners. In

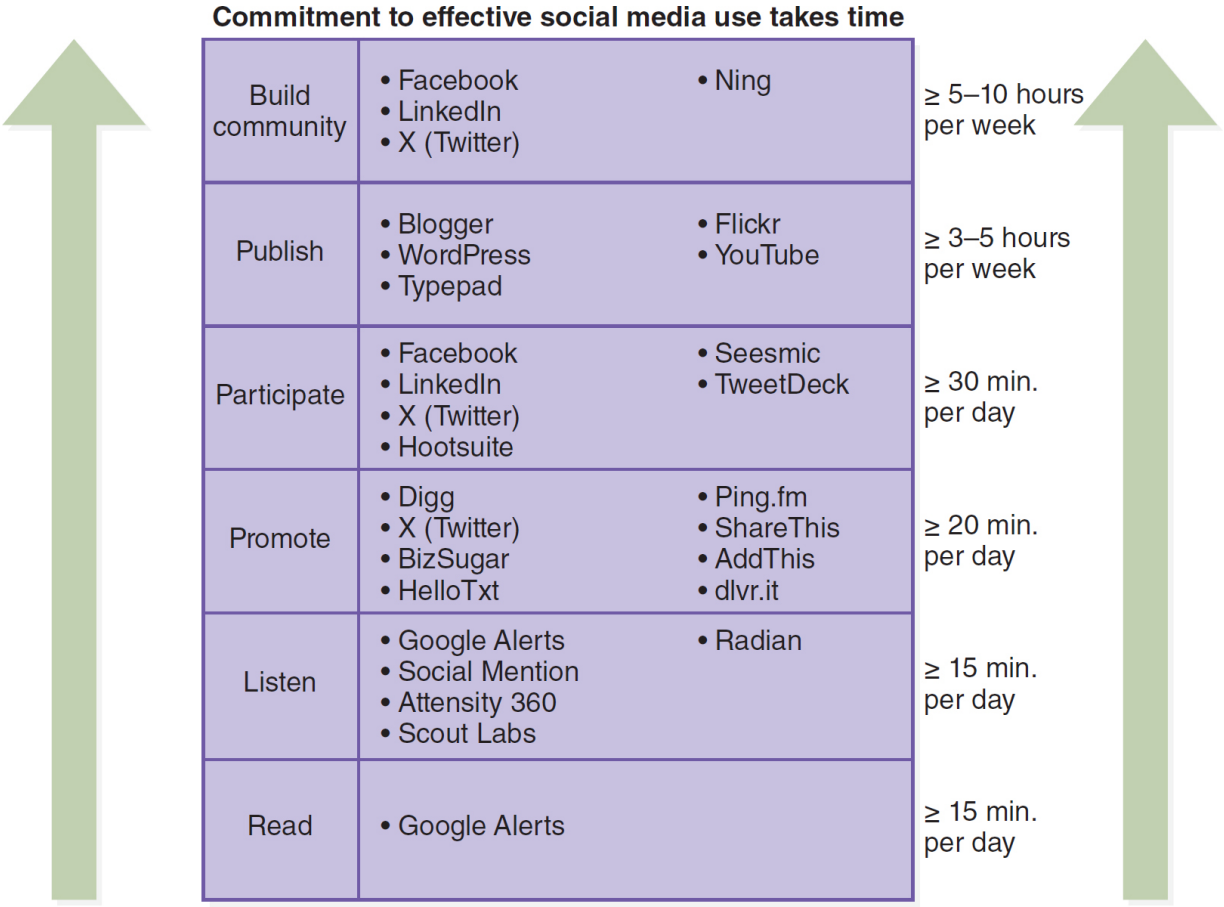
addition, web-based and place-independent learning allows anyone with access, anywhere in the world, to participate. Exposure to online learning during healthcare professional education programs will facilitate continuing professional education during the practice tenure. Related to this issue is the democratizing effect of online learning such that all students have the same opportunity to participate without judgment. Web-based classes provide an easily accessible permanent record, a convenience for both teachers and learners (Aquino-Russell et al., 2007).

One of the challenges and criticisms of online education has been that the instructor does not know whether the student enrolled in the class is actually the person who takes the test or writes the paper. But the same can be said for instructors in face-to-face classes regarding who actually completes papers and out-of-class assignments. The only sure thing is that if students test in a classroom with the instructor, the instructor knows that they are the ones taking the test. Thus, verification of students' identity is critical to ensure that credit is given to the student who completed the work or took the test, especially in an online testing environment. Learner identity verification tools continue to evolve. Some critics believe that as with other technologies, students can find work-arounds. To meet the federal regulations and secure the testing environment, many believe that instructors should use one or more identity verification tools combined with a method for live proctoring. It is imperative that nurse informaticists and information technology experts work with educators and administrators to determine the technology tools necessary to accomplish student identity verification, based on their specific infrastructure and needs.

It is important to use tools that facilitate learning, such as introducing social media into nursing education. X (formerly Twitter; https://twitter.com/home) can be used to focus and hone student perspectives. Each posting, or tweet, cannot exceed 280 characters. As learners critically think about what they want to add to the discussion, they must act as wordsmiths to express their views succinctly and concisely given the character limitation. Other social media that can be used in education include the following sites:

- Diigo (www.diigo.com), a social bookmarking tool to collect, tag, and share online sources (Meyer, 2015)
- Feedly (https://feedly.com/i/welcome), an online feed aggregator to notify the subscriber of new content on blogs and websites of interest (Meyer, 2015)
- Flickr (www.flickr.com), for photo sharing
- Instagram (www.instagram.com), for customizing and sharing photos and videos (Meyer, 2015)
- Pinterest (www.pinterest.com), a social bookmarking tool used to prime discussions (Meyer, 2015)
- Pixton (www.pixton.com), to create comics or cartoons
- Prezi (https://prezi.com), to create zooming presentations
- Scoop.it (www.scoop.it), an online content curation tool used to collect web resources, comment on them, and publish the source and commentary (Meyer, 2015)
- SlideShare (www.slideshare.net), a community for sharing presentations
- YouTube (www.youtube.com), to watch and share videos
- VoiceThread (https://voicethread.com), to share images, videos, documents, and commentary (Meyer, 2015)
- Wordle (www.wordle.net), to create word clouds from text

Students can use these sites to facilitate their presentations and for team collaboration. The use of social media not only exposes the students to their use but also promotes the development of skills that will support professional collaboration as students enter the practice arena. Meyer (2015) reported that using social media in education helps students put concepts in context, maintains currency in course content, and fosters a sense of community. **Figure 19-2** demonstrates the purposes and time required for proper use of social media.



Data from: Holly A. (2016). *Find 10 tips that help you take time to be social*. The Social Observer.

Figure 19-2 Social Media Time Estimates

Description

EDUCATIONAL APPLICATIONS FOR BLOCKCHAINS AND DISTRIBUTED LEDGER TECHNOLOGY

As you read about these applications, envision how this technology could work, and think about other educational uses for it.

DECREASE FAKE DIPLOMAS

There are more than 200,000 fake diplomas sold by fake diploma mills every year in the U. S., and recently there were arrests surrounding more than 7,600 fake nursing diplomas issued from Florida schools alone (Bernstein, 2023). The verification process is personnel intensive, and some have suggested that **blockchain** technology can be used to store these credentials. Learning Machine "has collaborated with the MIT Media Lab to launch **Blockcerts**—an open infrastructure for creating, issuing, viewing and verifying blockchain-based certificates" (Vander Ark, 2018, para. 4). The issue of diploma fraud and fake diplomas could be eliminated with the use of blockchains because Blockcerts would facilitate verification of blockchain educational credentials (McArthur, 2018). According to Coca (2021), if all institutions would put blockchain in place to protect against fake information, the number of diploma mills and fake universities would decrease.

FILE STORAGE AND SECURITY

Educational entities must protect their student information from being corrupted, altered, or lost. **Distributed ledger technology (DLT)** cloud storage could offer a safer and less expensive alternative to traditional options (Vander Ark, 2018; Yedigaryan, 2019).

LIBRARY HOLDINGS

DLT could facilitate a library's expansion of its "services by building an enhanced metadata archive, developing a protocol for supporting community-based collections, and facilitating more effective management of digital rights" (Vander Ark, 2018, para. 34).

CREDITS OR CREDENTIALS FROM MULTIPLE EDUCATIONAL ENTITIES

Blockchains or DLT could track and maintain credits received over time from multiple educational entities. This technology would provide authentic, verifiable, accurate records of student credentials and competencies (McArthur, 2018).

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Hybrid or Blended Delivery

Traditional courses are more frequently being offered as online virtual classes (i.e., **distance education**)—learning that occurs other than in the traditional classroom and consequently requires special course design, planning, techniques, and communication. A **hybrid** of this delivery mode includes learning in which traditional classroom time is enhanced or broken up with online components, thereby creating a class in which **blended** learning occurs. Forms of hybrid learning include **web-enhanced** learning, such as asking students to blog responses to a reading or class discussion, and learning that takes place in and makes use of smart classrooms (e.g., teaching in a wired room equipped with classroom learning technologies).

Smart classrooms, also known as digital and multimedia classrooms, integrate computer and audiovisual technologies by providing a ceiling-mounted projector with an access point at the front of the room, an instructor podium or workstation, sound, and network access. An enhanced smart classroom also provides networked student workstations instead of traditional desks, allowing students to follow along online and perform network or web searches, chat, blog, or a myriad of other activities as directed by the professor. For example, at the Penn State College of Nursing, users can access announcements, course materials, faculty information, websites, and other tools through the electronic course

management system, which enables the nursing faculty to extend learning beyond the physical classroom walls.

Competency-Based Learning

More robust LMSs are particularly well suited to support competency-based learning. Nursing competencies have been well defined by professional and accrediting organizations, such as Quality and Safety Education for Nurses (QSEN); American Association of Colleges of Nursing (AACN), through its Technology Informatics Guiding Education Reform (TIGER) initiative and the essentials of nursing education delineated for undergraduate and graduate study; and Healthcare Information and Management Systems Society (HIMSS), through its promotion of informatics competencies.

Database technologies within LMSs offer the ability to track competency achievement, as Pijl-Zieber et al. (2014) explained: "Such technologies could be shared, at least to some degree, between nursing student and nursing instructor, much like clinical evaluation tools are shared on paper, to jointly track skills, knowledge, abilities, critical thinking, clinical reflection, and developing competence" (p. 677).

Technology Tools Supporting Education

Certain social trends emerging from the morass of both traditional and innovative technology tools include the use of technologies attempting to meet the needs of members of the **Net Generation**, or the millennials (i.e., those born between 1981 and 1996). These students have grown up inside a wired world of instant access and online everything, and they are connected, digital, experiential, and social learners. Through the use of software, hardware, drivers, dedicated servers, plug-ins, and internet connections, students can chat, collaborate, play games, or interact electronically with a peer in some way, all with little to no learning curve or effort. Because visual media are now the vernacular of this highly digital culture, such tools might take the shape of interactive tutorials, a created city within a virtual reality landscape, high-fidelity simulations, serious games, or even a multimedia action maze that prompts users to choose different outcomes within a scenario. **Generation Z (Gen Z)** learners are those born between 1997 and 2012. Schrader (2022) believed that their learning must be flexible so that they can self-pace and be highly collaborative in nature. These learners want their reality to be seamless from the real world through any of the virtual reality experiences.

Members of Gen Z are entering nursing schools and the workplace. This generation is currently the most racially and ethnically diverse of all the other generations, and they are very comfortable with technology, especially when using the internet and wireless devices to obtain information when they need it. The number of technologies and devices they use could cause them to mainly interact virtually; their expert use of sophisticated digital tools could result in immature social skills and the inability to make and maintain relationships, placing them at risk for isolation and related issues of anxiety, loneliness, and depression. Stillman (2019) stated that "about half of Generation Z spend 10 hours or more each day online. . . . [The] favorite social media sites of Generation Z include

Instagram, YouTube, and Snapchat" (para. 2). Gen Z will be a 2.56 billion population by 2020. When Gen Z grows up, they'll make up 40% of U.S. consumers. In view of the size of the Gen Z population, all educational institutions must consider and adjust to their learning needs (Morgan, 2020; Todorov, 2023).

Regardless of the particular tool employed, technology can perform only as well as the pedagogy that drives it. Therefore, the faculty and learners must be considered and supported in order to sustain the nursing programs.

Tutorials

The modern **tutorial** mimics lectures by guiding users through a series of objectives or tasks, which they are usually allowed to complete at their own pace (Edwards & Drury, 2000). Generally, tutorials stand alone as autonomous multimedia that may use animation, text, graphics, sound, questions, and various kinds of interactivity to engage and intrigue the user. They tend to promote active learning by prompting users to answer sets of questions, follow clickable **hypertext**, or complete quizzes. For example, users might be asked to fill in worksheets after reviewing anatomy concepts, take a quiz, post an answer to a question, or click through a scenario by choosing the best course of action in a mock clinical situation.

Some tutorials, such as those used by medical students at the Morgan Stanley Children's Hospital of New York, are designed to be brief (10 minutes), interactive, very focused, and immediately relevant. In this case, medical students bustling through a busy clinical rotation who accessed the tutorials actually raised examination grades (Pusic et al., 2007).

Because most students benefit from being able to contextualize a lesson's framework and purpose, the most effective tutorials provide users with understandable navigation, such as a table of contents at its beginning, or additional navigational aids, such as icons, buttons, or text, that indicate where and how they need to progress (Dewald,

1999). Effective tutorials surpass the simple presentation of information in a web-based format; instead, they address certain pedagogical and student-centered needs by identifying and considering specific factors, such as instructional content, the educator's purpose and teaching goal, the initiative's overall purpose, the potential need for special conceptual input, the learners' ultimate objectives in completing the tutorial, and the standards that determine what qualifies as successful completion of the tutorial (DeSantis, 2002).

Although most tutorials are created to stand alone, some of them may also benefit and supplement face-to-face instruction, such as the interactive information skills tutorial developed at the Institute for Health and Social Care Research in Salford, United Kingdom. This tutorial divides a traditional lecture series into chunks and incorporates questions into the text that would normally arise during the session and provides hyperlinks to the answers. This organization allows users to browse to different parts of the tutorial, open a database in a new window to perform a practice search, and access other features (Grant & Brettle, 2006). In all their iterations, tutorials urge students to hone and develop effective critical thinking skills. Short tutorials may also be created on an organization's intranet to educate practicing professionals on a new policy, procedure, organizational initiative, or healthcare technology. Since the tutorial is electronic, access and time spent on the tutorial can easily be tracked.

Case Scenarios

Professional organizations are increasingly recommending performance-based assessments of students in professional degree programs, and enacting case scenarios provides an opportunity for students to practice procedural responses and improve patient safety. The **case scenario**, a form of problem-based learning, has evolved and is now available through simulation software and virtual reality programming. This kind of learning assessment, in which

students must respond within context to a perceived situation rather than a theoretical or fact-based question, allows educators to gauge procedural knowledge and determine how well a student executes a skill or applies concepts and principles to specific situations (Garavalia et al., 2008). For example, in a clinical context, a student could explain a specific procedure, but such knowledge is declarative rather than procedural; therefore, for some evaluators, it is not as valuable. Conditional knowledge is also often reflected in procedural knowledge that demonstrates a student's ability to know when and why action is or is not taken and how. As more programs move toward interprofessional education, case scenarios are a great way for students to hone collaboration skills and gain an understanding of the roles of other professionals.

Portfolios

Portfolios in healthcare professional education have grown in popularity as useful tools for documenting students' exposure to educational experiences. A **portfolio** allows a student to document a variety of unquantifiable skills, such as creativity, communication, and critical thinking. Further, portfolios can reflect achievement of goals, self-evaluation, and professional development and provide a way for returning students to log and document past work or life experiences in a creative but structured way without taking a standardized test. The usefulness of a portfolio for an undergraduate depends on a structured system of organization, such as an identification page with a résumé, a table of contents, and separate and clearly marked sections. In this way, portfolios can monitor program outcomes, positively influence employment and graduate school admission, and provide a clear snapshot of a student's strengths and abilities. See **Box 19-1** for an overview of electronic portfolios and specific information on developing a professional portfolio.

BOX 19-1 WHAT IS AN ELECTRONIC PORTFOLIO?

Glenn Johnson and Jeff Swain

Today's information technology infrastructure allows users to easily build web-based collections that include **evidence** of their knowledge and skills. Users can upload artifacts that represent evidence of their learning experiences, inside and outside of the classroom. Electronic portfolios (e-portfolios) may also contain a blog element where students reflect on their total experience and demonstrate growth in their areas of study.

E-portfolios can be built using a range of technologies. Some individuals use PowerPoint presentations to capture and present evidence. Web-based e-portfolios are built using common **web publishing** tools to create web pages, such as Web 2.0, Web 3.0, or open source tools; the web pages are then published on the internet. Web 3.0 and an increasing number of institutional e-portfolio systems have emerged to transform how students, educators, and institutions can log on and then upload, enter, and share information or evidence related to their experiences. Students and educators can interact, collaborate, and share learning accomplishments. Examples of e-portfolio systems include the following:

- Association for Authentic, Experiential, and Evidence-Based Learning: https://aaeebl.org
- Digication: www.digication.com
- Facebook: www.facebook.com
- LiveText: www.livetext.com
- Myspace: https://myspace.com
- PebblePad: www.pebblepad.co.uk
- Typepad: www.typepad.com
- Watermark: www.watermarkinsights.com

WHY CREATE AN E-PORTFOLIO?

Although academic institutions may use e-portfolios for assessment of student learning, for the individual, e-portfolios are all about opportunity. Such opportunities might include supporting a working relationship with a mentor, networking with other professionals, or representing certain qualities and characteristics to prospective employers. The e-portfolio allows students to track, monitor, and assess their learning to gain significant insights throughout their program of study. In all of these cases, going through the process of

developing an e-portfolio requires critical examination of which qualities make individuals who they are and why these qualities are important to them and their profession. It is important for all professionals to have a foundational understanding of where they are in their career trajectory and how this fits with their long-term professional goals.

Practically speaking, e-portfolios are efficient. When introducing oneself in an email message, a self-starting individual who has taken the initiative to develop and publish an e-portfolio can add this line to the message: "Here is a link to my e-portfolio." The recipient can click on this link, which automatically opens that individual's e-portfolio in a web browser. Metaphorically, the senders of such messages have just walked into the recipient's office with information that illustrates who they are, what they know, what they can do, and what they value as important; they have just walked in with what could be a multimedia showcase of their qualities. The internet is a very powerful communication medium, and individuals with professional e-portfolios are simply taking advantage of this fact.

E-PORTFOLIOS IN HIGHER EDUCATION

As an instructional strategy, portfolios have been around for a long time. Instructionally, portfolios, whether electronic or paper based, require students to demonstrate or provide evidence that they have attained specific learning outcomes. For instance, in the arts, portfolios have been used to demonstrate the depth and breadth of the work of an artist. Although performance-based programs of study are more likely to be familiar with the concept of the portfolio as a demonstration of what a student knows and can do, other areas of study have also begun to adopt this method of assessment.

Portfolios can be particularly helpful in areas where higher-level thinking and analysis are essential. For instance, being a good healthcare professional encompasses much more than simply being able to get high scores on examinations. Professionals need to be able to collect information, analyze the information presented and relate it to past experience, apply related knowledge, and evaluate various options and, from all this, present a diagnosis and a plan of action. In short, healthcare professionals need to be able to think critically and make informed decisions. In learning to become a healthcare professional, portfolios can be used to capture, support, and improve this type of thinking as it develops.

Like the artist, the healthcare professional student can connect, share, and present cases and findings and include with this evidence the **reflective commentary** that serves to unveil how they arrived at a decision, which information or experiences were vital, and how their action plan evolved. However, given the vast variety of evidence that individuals might potentially

use to represent themselves, what should one select, and how should this be shared?

E-PORTFOLIOS FOR PROFESSIONAL DEVELOPMENT

Using an e-portfolio to support **professional networking** involves a predetermined and focused purpose. This purpose may be to foster better communication between oneself and a mentor, or it may be to establish how what a professional is doing fits with the goals of the institution for which the individual works or would like to work. A professional e-portfolio is evidence based and uses this evidence to make a case that highlights the individual's capacity not only to perform but also to grow and develop professionally within their chosen field.

THE E-PORTFOLIO PROCESS

The four steps involved in developing an e-portfolio are recursive in nature, meaning that during the process, one can backtrack to fill in missing pieces or reevaluate earlier decisions that were made. The four steps are (1) collect, (2) select, (3) reflect, and (4) connect. See **Figure 19-3** for an image of the portfolio creation process.

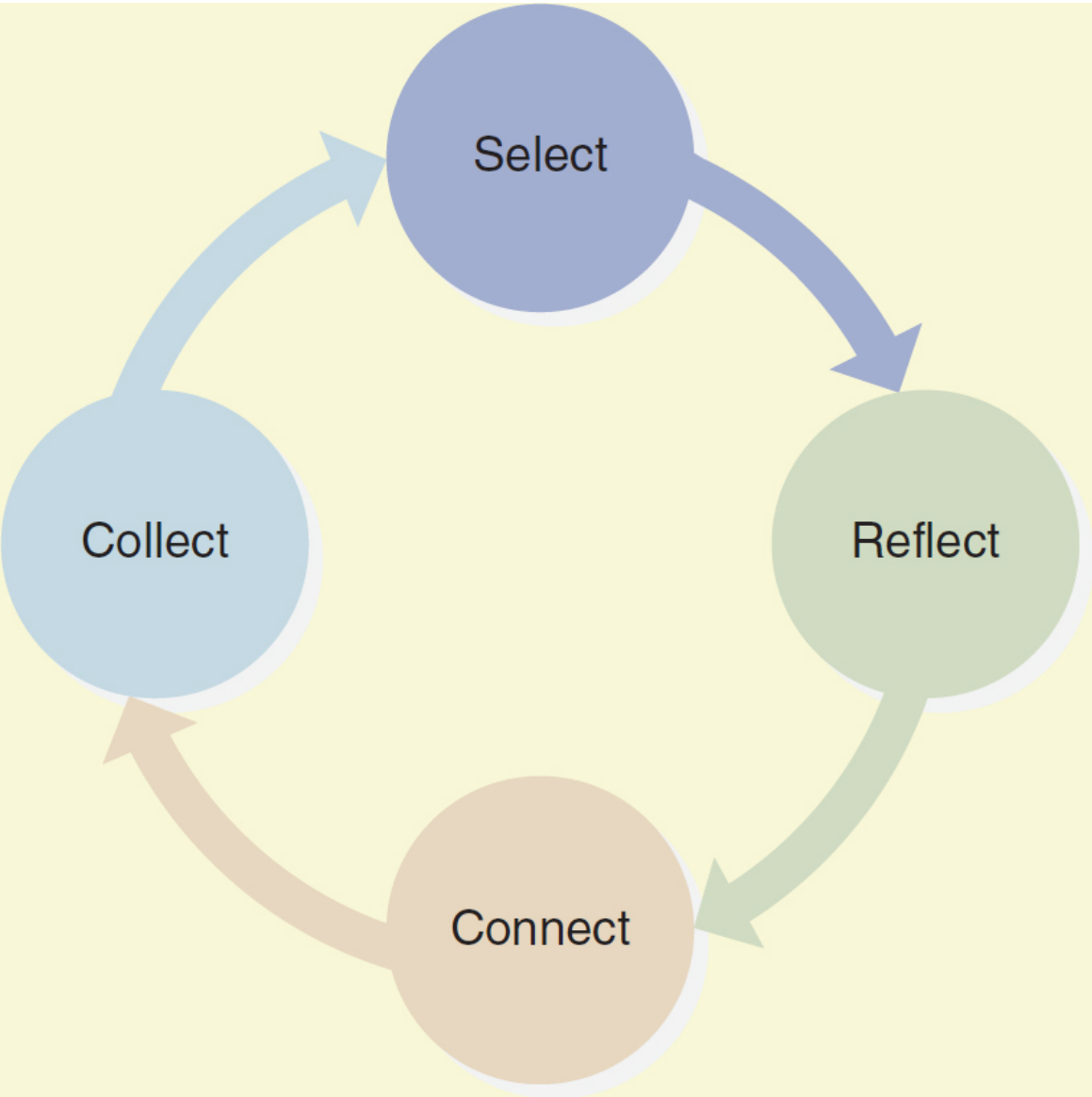


Figure 19-3 Portfolio Creation Process

Collect

Evidence should demonstrate what a person knows and can do or the values that they hold as being important. When it comes to developing e-portfolios, it is important to think of evidence in very broad terms. This evidence might include the results of what someone has learned in courses taken as a student, especially in terms of demonstrating a new skill or knowledge of a subject. More importantly, evidence can come from experiences that take place outside of the classroom. For instance, someone may have been involved in an internship or clinical observation where they had the opportunity to connect what was learned in the classroom with how this

information is applied in a real-world setting. Such an experience not only is valuable but also represents the individual's understanding of how this knowledge can be applied; thus, it enhances others' perceptions of the depth of what the person knows.

Résumés are evidence documents. They are very important, and every professional should have an updated copy available. However, résumés simply list an individual's experiences or accomplishments. By comparison, e-portfolios go beyond the résumé to emphasize personal attributes that are very important in the specific profession. These attributes include, but are not limited to, interpersonal skills, leadership skills, appreciation of diversity, ability to work in a team, and self-sufficiency. These attributes are difficult, if not impossible, to demonstrate in a résumé. When reflective commentary accompanies evidence of an individual's involvement, these attributes and values can become the highlights of an e-portfolio.

Select

Everyone has their own unique pool of evidence from which to pull, and over time this evidence pool can become quite large. What will someone choose to feature and why? Putting together a professional e-portfolio requires that several intertwining questions related to purpose and audience be addressed.

What is the purpose? What is it that someone is attempting to gain by putting an e-portfolio together? Is the purpose related to personal development (i.e., feedback and advice about the professional direction that is being taken)? Is the purpose to connect with colleagues? An individual may, for example, be interested in using their e-portfolio to find a job or gain admission into a graduate program.

Although an e-portfolio can link to everything that a person has accomplished, this may not be the best strategy. Instead, it is essential that an individual consider the audience and establish a plan that enables them to select the most appropriate pieces of evidence for their particular purpose and audience. A helpful way to start is to select the top five pieces of evidence that support the plan. Next, the individual should consider why they selected these pieces of evidence. What is it about each piece of evidence that makes it representative of who the individual is and what they know, can do, and value as important?

Reflect

Reflection and reflective commentary take an e-portfolio to the next level. This component may take the form of a single reflective statement, or it may be attached to the evidence throughout the e-portfolio. Reflective comments should open up a window into why an individual thinks this evidence is important, the ways in which the individual values what they learned, or why

the individual thinks it is important for the larger profession. For instance, the individual may present an experience where they were challenged to provide assistance. Describing this experience would be important; however, the reflective comments can extend this description, enabling the individual to talk about the alternatives considered as the basis for how they made a decision to provide the specific type of assistance and the manner in which it was provided. By itself, a description of this experience is good. With reflective comments, readers have a much more thorough perception of and insight into an individual's professional thinking. This is where having a blog element as part of an e-portfolio becomes extremely powerful.

Unlike static web pages, a **blog** page is a space designed to be interactive. The blog owner posts commentary, thoughts, and experiences for others to read and respond to. Regular entries on a blog give others a reason to return to one's e-portfolio site repeatedly. It is an opportunity to share one's perspective on topics of interest and is critical to the chosen field. A blog is a place where conversation happens. It provides a nice counterbalance to the static web pages, such as a résumé and project pieces.

Most blogging platforms allow users to select from a range of templates, which include a blogging element along with static web pages. Platforms such as WordPress, Moveable Type, and Google are free for at least the basic service, which enables the user to create a dynamic e-portfolio without having to build web pages. Most platforms allow entries to be in both text and multimedia format, so the blog becomes the perfect place for personal expression. A blog is quickly becoming a standard part of an e-portfolio.

Connect (Connections) and Feedback

The connection and feedback step is important to validate the assertions people make about what they know, understand, or value. Individuals may choose to receive feedback from those who are close to them and then from there reach out to others, who may provide different perspectives. For instance, if healthcare professionals were thinking about using their e-portfolio to apply for a position, they might want to start by getting feedback from friends and family. They might also share their e-portfolio with a mentor or faculty member, which raises the bar by getting professionally grounded feedback before sharing their e-portfolio with a prospective employer.

CHALLENGES AND ISSUES: PRIVACY AND SECURITY

The ease and popularity of web-based social networking and professional e-portfolio tools also raise several challenges and issues for users. Never before has information for individuals been so accessible, nor has such personal information been so readily made public. For this reason, issues related to

privacy and security need to be addressed. What might be appropriate socially can be deadly in a professional context.

E-PORTFOLIO PROCESS: SUMMARY COMMENTS

In summary, one might think about the process of developing a professional e-portfolio as boiling down to the telling of a rather simple story, albeit a story that has three parts: looking back, looking around, and looking ahead. Readers should think of their own evidence pool as they answer these questions:

1. Looking back: What have you done? In which activities and with which organizations have you been involved? Where have you been? With whom have you worked? How did this help get you where you are today?
2. Looking around: In what are you currently involved? Why are you doing this? What are you getting out of it?
3. Looking ahead: Where would you like to be in 2 years? Where would you like to be in 5 years? Why do you feel this way? What makes you think your goals are realistic?

Simulations

Simulations have been widely used within healthcare circles, but they experienced a recent upsurge due to the pandemic and the widespread availability of high-quality simulation equipment and software along with a reduction in the cost of this technology. Ranked by fidelity, or the level of realism the equipment provides, simulation may take various forms, from mannequin-based to **computer-based** simulation in which software is used to simulate a subject or situation (e.g., an interactive tutorial featuring a nurse–patient situation) to full-scale simulation in which all the elements of a healthcare situation are recreated using real physiology, people, and interaction to, as closely as possible, resemble a real-life environment. These immersive virtual simulations make the learners suspend reality and feel like they are really in the situation. Simulation scenarios aid nursing instructors in assessing competency achievement. For a more comprehensive discussion of simulation as a teaching and learning tool, please see Chapter 20, *Simulation,*

Game Mechanics, Virtual Worlds, and the Realities in Nursing Education.

Virtual Reality

In traditional **virtual reality (VR)**, the user receives multiple sensory inputs either mediated or generated by a computer through nasal stimulation as smells or scents, visual stimulation (i.e., glasses, goggles, and screens), audio input (i.e., earphones, microphones, and synthesizers), and touch (i.e., gloves and bodysuits). A form of simulation training that was once considered a science fiction technology of the future is the increasing use of virtual reality healthcare training.

Because virtual worlds foster unintentional learning through gamelike technology in which students discover and create knowledge to accomplish something rather than experiencing traditional outcome-based learning, their experiences may result in greater comprehension and deeper knowledge. In a virtual clinical scenario, for example, a simulated, immersive environment presents invaluable learning opportunities for the student who is assuming the role of healthcare provider. Faculty can monitor the interaction and interrupt as necessary to leverage those teachable moments and assess the learner's thought process and proposed next actions to apply specific skills within a clinical setting. Scott (2018) stated that VR "is being incorporated into college classrooms all over the country. Making sure they [the classrooms] are ready for deployment is just as important as the lessons being taught" (para. 1). This surge occurred prior to the pandemic and then the pandemic helped to continue its use. Because so much of the data nurses rely on are complex and because so many patients' cues are lacking in concrete language or responses, the animated, immersive, three-dimensional environment of virtual worlds allows students to practice skills, try new ideas, and learn from their mistakes while receiving feedback from educators within a globally networked classroom environment. Virtual reality tools are a great way to implement competency-based

education. Some students may struggle to participate in virtual communities for various reasons. Increasing comfort with multidisciplinary learning among students and educators improves patient safety and encourages the refinement of best practices. Chapter 20, *Simulation, Game Mechanics, Virtual Worlds, and the Realities in Nursing Education*, provides a more comprehensive discussion of this technology.

Internet-Based Tools

The consensus in nursing education suggests that any technology that allows users to interact and engage with materials and one another is useful. More specifically, the Foundation of Knowledge model qualifies this observation with the caveat that technology must display user-friendly capabilities to provide benefits to its users, thereby allowing students not just to find information and one another online but also to engage, challenge, and institute their discoveries. Providing nursing students with easy-to-use, free internet tools for reaching the first step in this process (i.e., gaining access to materials and peers) has been addressed by the proliferation of communication technologies available to any user with an internet connection. Beyond the gadgetry, with the development of new strategies, practices, applications, and resources in technology comes the need for instructional strategies that not only appeal to this newer generation of students but also enhance learning. Such strategies, when coupled with easily accessible and highly functional tools, encourage nursing students to see beyond the right answer and seek out information that encourages them in developing approaches to issues and resolutions for problems. According to Hughes (2022), "Make sure that your strategies are agile, customizable, and ready for the momentum of Generation Z" (para. 33).

Digital Books (eBooks)

There is an unmistakable trend toward the development and use of digital books. It is clear that the ability to create eBooks that use the interactional capabilities brings more to the learning experience than just replicating a print-based text as an eBook. Affordability is one key advantage of eBooks. The possibility also exists of embedding content into the eBook, which could provide a link to a multimedia video or a website. The good news is that the quality of eTextbooks

is greatly improving. It is a trend worth following in the future, especially because "Gen Z might not be picking up a novel, but they are reading content on the internet, and they're finding themselves represented in formats like manga" (Jensen, 2019, para. 22). These learners are used to collaborating and interacting digitally and are looking for the same in their learning episodes.

Webcasts and Webinars

A **webcast** is a broadcast of a presentation delivered by way of the web. Webcasts offer great potential for helping students and faculty to engage with both information and one another globally by tapping into students' multiple intelligences to enable them to access what they need. Because of the growing ease of producing streaming video and subsequently delivering it via larger bandwidth, webcasts have grown in popularity and are especially favored by programs that feature distance education components. Although some institutions create their own webcast delivery system, most users rely on a few standard providers, which in turn present the webcast online. Although these presentations are often delivered live, which allows audience members to participate in the broadcast, many instructors use webcasts as an access point for prerecorded archives of lectures and presentations by experts whom their students would not otherwise have the opportunity to see or hear. Studies show that students enthusiastically embrace webcast technology by accessing archived presentations more repeatedly than traditionally filmed sessions of guest lecturers; this dynamic level of engagement aids learners in better grasping the subject matter, especially when they are prebriefed and understand the learning outcomes before they view the webcast.

A **webinar** is a web-based seminar that uses web conferencing software, which allows educators to share their computer screen and files and interact with their students. Some webinar services allow for interactive sessions in which the audience can engage with the presenter. According to Waas (2019), "interacting with the hosts

leads to higher engagement and longer total time spent on the webinar" (para. 11). Webinars are typically delivered live but can be recorded. In this geographically dispersed online world of learners, webinars provide another avenue for sharing and collaborating.

There is a key difference between webcasts and webinars. Webcasts present material to the audience with limited or no interactivity. By comparison, webinars are generally live, interactive, educational sessions. Both of these venues provide access to the educator and, depending on the level of interactivity, to other learners.

Searching

One of the most common and proliferative search tools in technology today is the wiki. **Wikis** are websites or hypertext document collections that allow users to edit and add content in an open-ended forum. The appeal of (and objection to) wikis resides in their ability to let anyone with an interest and an internet connection participate in a once-exclusive community of knowledge creators and seekers. As an environment that encourages practice and learning, wikis support learning communities in which learners collaborate online or virtually. Higher education has evolved from a place of straightforward knowledge transmission to a place where one strives to become a member of an expert community, and wikis promise to create opportunities for individuals to participate in this community in heretofore untapped ways.

The most objectionable aspects of wikis are their lack of organizing principle (many are organized alphabetically) and the ability for anyone to edit entries, the latter of which creates new intellectual property rights challenges. Wikipedia, for example, is the best-known wiki project on the web; it is an online encyclopedia of sorts whose open access policy regarding its content keeps educators and professionals wary of inaccurate information to be found there. Wikipedia works well as an initial source of information on a topic or as a quick overview reference, but we must educate

our learners that it should not be relied on as a sole source of information. For more information on the appropriate use of Wikipedia, see this online tutorial: https://libguides.cmich.edu/web_research/wikipedia.

Instant Messaging

Instant messaging, one of many collaborative web chat tools available to any user with a computer and internet access, continues to establish itself as a working, useful tool for informatics learning by providing instant access to and communication among people, information, and technology. Although some **instant message (IM)** services provide voice and video messages, all instant messaging (IM'ing) clients provide text in **real time**, which allows users to interact in the form of an on-screen conversation through a technology that is free, already quite popular with users, and web based; does not require additional hardware or software; and has a very low learning curve for those few to whom it is unfamiliar. Beyond having a real-time conversation, IM'ing an individual allows the user to share links, pictures, and files. When learners are logged on, this kind of easy accessibility allows them to collaborate, seek real-time help from professors or librarians, and engage others working on the same learning content.

Chats and Online Discussions (Blogs)

Real-time chats occur all over the internet, at every hour of every day. The best-
known chat tools are instant messenger clients, but chatting also refers to real-time discussion venues in which users meet in virtual chat rooms to engage in conversations by posting messages. Chat rooms provide a comfortable, recognizable way of communicating for Net Generation students used to surfing the web and interacting online. In a chat, students can meet, discuss, and engage one another over any topic. Chats take various forms, the most complex

of which involve highly evolved virtual communities in which users step into various rooms where they interact with other individuals who are in the room at the same time. Initially, the exclusive purview of gamers or hard-core programmers who created private online communities, chat rooms now exist for a wide variety of topics and interests.

Web logs, also known as blogs, have emerged as low-investment and easy-to-use writing tools. Their very setup and appearance enhance health professionals' communication, writing, reading, information-gathering, and collaboration skills. Blogs are a kind of online journal created by individuals who then invite comments from visitors to that web space. Compared to technically complex online projects, such as tutorials and various multimedia, blogs are immediate, free to set up and access with an internet connection, and easily negotiable by even the technically ambivalent. They are especially useful for study groups interested in reflecting on material and evaluating ideas in a collective, collaborative way, since blogs present a built-in discussion area to the user. Blogs are a great way for students and professionals to reflect on and share clinical experiences and questions with one another. It is important, however, to be mindful of protecting private health information and to share within the confines of Health Insurance Portability and Accountability Act (HIPAA) guidelines.

Electronic Mailing Lists

One low-investment information-gathering tool for use by nursing professionals is membership in an **electronic mailing list**. These electronic discussion groups use email to communicate and promote communication and collaboration with others interested in a particular field of study since they have very few requirements for participating, usually just a free subscription and email capability. Such lists are available on any subject, but most lists share common features, such as the need to subscribe and then log on to participate. The moderators of an electronic mailing list have specific

instructions on how to post messages and set subscription controls. Posting information means that when a user replies to a topic thread, they generally have sent information to every member of the list. Like other technologies, the capabilities of electronic mailing lists continue to change and expand and provide ongoing viability for use in nursing education.

Portals

Like electronic mailing lists in the way they deliver specific information to one's email, a **portal** organizes information from web pages into simple menus so that users can choose what content they want to view and how to view it. For example, WebMD is one of the most popular and best-known portals, which allows users to create accounts, bookmark their favorite information, and sign up for email notifications. Portals, like most web technologies, require an internet connection and a free subscription, which allows the user to log on.

Podcasts: Audiopods and Videopods or Videocasts

A **podcast** is an audio recording linked to the web that is then downloaded to an MP3 or **MP4** player, a smartphone, or a computer through which the listener can then access the recording or video. An outgrowth of the Apple iPod market, podcasts are developed and delivered by way of the internet and require minimal investment—namely, a microphone, an internet connection, and (often free) editing software.

Beyond possibilities for global accessibility to whatever information the user may record, podcasts allow for automatic updates in the form of a **really simple syndication (RSS)** (also known as a **resource description framework [RDF]** site summary) feed, which lets subscribers receive an automatic notification whenever a podcast is updated. Refer to **Box 19-2** for more information.

BOX 19-2 PODCASTS

Jackie Ritzko

A basic web search using the search term "free nursing podcast" produced over 1 million hits on one search engine. But what does this information mean in the context of nursing informatics? The implication is that there are many resources on the internet that involve podcasts with a nursing focus. How these sites might be of use to a professional in the nursing field is the focus of this feature. Before any discussion of the educational uses of a technology tool can take place, however, there needs to be an understanding of the hardware, software, training, and support that are required to use the tool as well as the history of the development of the tool.

Podcast is a term coined from the words *iPod* and *broadcast*. **iPod** is the name given to a family of portable MP3 players from Apple. MP3 is a common file format for electronic audio files. Audio files—in particular, MP3 files—can contain verbal speech, music, or a combination of both. MP3 files can be listened to using an MP3 player. MP3 players can be portable devices, such as the iPod, or simply software that is installed and used on a computer, tablet, or smartphone. Thus, a podcast is simply an MP3 file that can be played on an MP3 player. *Broadcast*, in its simplest usage, refers to the ability to send out. In terms of podcasts, broadcasting is the ability to share MP3 files in such a way that the files are delivered to the user, through a subscription, whenever new versions are available. This ability to share and access the most up-to-date resources is a great advantage, especially for the educational community.

The discussion now turns to the function of podcasts, ranging from the more basic to the more advanced functions: finding, listening to, creating, and sharing podcasts. Finding podcasts at a minimal level requires only an internet connection and a web browser. As noted earlier, a basic web search for the term "free nursing podcast" produced many sites. Performing a basic web search, however, may provide a user with only limited search capabilities. An **MP3 aggregator** is a program that can facilitate the process of finding, subscribing to, and downloading podcasts. One popular aggregator is Apple's iTunes, which is a free program available as a download at www.apple.com/itunes. Although iTunes is widely used, it is not the only program of this type. A program such as iTunes gives the user the ability to search for podcasts based on many criteria, including category, author, or title. The iTunes program provides access to audio downloads that may be either songs or podcasts. In both cases, users may find downloads that are free and those that require payment.

Because podcasts are largely MP3 audio files (Advanced Audio Coding [AAC] is a newer format but is not as widely used), an MP3 player is needed to listen

to a podcast. As noted, listening to a podcast can be done on a smartphone, a computer with an MP3 player, or a portable MP3 player. Podcasts can be downloaded in two ways: manually or by subscribing to a podcast. In the case of a subscription, once a new track is added to the podcast, iTunes automatically delivers it to a computer. Continuing to use iTunes as an example, once a podcast is found, it can also be manually downloaded from iTunes to a computer. Once on the computer, it can be listened to or transferred to a portable device or accessed via a tablet or smartphone.

Users may also choose to produce or record podcasts. Typically, as with most technology solutions, hardware and software requirements must be met to create podcasts. The hardware for recording a podcast can vary. In a stationary setup, a microphone can be connected to a desktop or laptop computer. Stand-alone audio recorders can also record podcasts, and some MP3 players contain built-in recorders. Free recording software is available for most computer platforms.

Sometimes a podcast is created for the sole use of the creator. More often, however, a podcast is created with the intention of it being shared with and listened to by others. Podcasts can be stored on web servers for distribution and shared via tools such as iTunes. Within iTunes, for example, educational institutions are able to host podcasts in the area known as iTunes U.

Podcasts have many uses in education in general and in nursing education in particular. Informal learning can take place when a nursing student listens to nursing podcasts. Listening to or creating podcasts may be a formal class assignment, which provides new ways to interact with course material.

Short discussions of what is new in the field may appear as podcasts on the internet, in particular on news and research sites. Learners may rely on the portability of MP3 players to take learning with them on the road. Commuters, walkers, and joggers are often seen listening to MP3 players. Because creating podcasts is relatively easy and inexpensive, such presentations can be produced by students as review files for common terms or used as ways for students to self-assess their ability to discuss topics. The uses of podcasts from an educational perspective are limitless.

Bringing the discussion of podcasts back to the Foundation of Knowledge model, for each task or process in the model, one can see how podcasts fit with that concept. Podcasts can be used to acquire new knowledge from sources on the web. Listening to podcasts provides learners with another tool for learning in addition to readings and lectures, thereby addressing a wider audience whose members have varying learning styles. Because podcast creation is simple and inexpensive, podcasts are an ideal way to generate and disseminate knowledge.

Audiopods

Audiopod is a term used to describe a traditional, or audio-based, podcast. Participating in podcasting can exercise not just basic technology skills but also writing, editing, and speaking skills. An excellent exercise for learners could be in the creation of the audiopod, using critical thinking to write the script and deliver the information. The technology itself allows global access to information by faculty, teachers, and learners anywhere, anytime. Both faculty and students can create audiopods with little difficulty to share additional class materials, updates, and even entire lectures.

Videopods or Videocasts

Like an audiopod in setup and accessibility, a **videopod** is a podcast that provides video in addition to audio functionality. Faculty might use videopods to demonstrate concepts and skills or even interview experts in the field and assess student progress.

Multimedia

As technologically savvy students continue to demand accessible, interactive learning tools to keep them engaged, an increasing number of LMSs are incorporating or interfacing with multimedia tools that permit videos or other media to be embedded so that interactive exercises can be generated using the media. They interface with applications such as those that will upload a video and generate a script from the video so that both can be embedded into the LMS for the learners to view. The term **multimedia** refers to a computer-based technology that incorporates traditional forms of communication to create a seamless and interactive learning environment, such as interactive tutorials, streaming video, and problem-solving programs. With the new user-friendly advances in multimedia creation, faculty members are able to add such innovations as simulations and virtual reality to their healthcare training, providing a way for students to learn procedural skills, such as insertion of needles and physical assessment, without any risks to an actual patient.

Research suggests that the seeing, hearing, doing, and interacting afforded by multimedia facilitates learning retention, with multimedia being at least as effective as traditional instruction but offering the benefit of greater learner satisfaction. As always, the faculty must design or lead the development using appropriate pedagogy as they intentionally combine the text, graphics, video, animation, and sound of their multimedia product. Some schools of nursing have instructional designers and multimedia developers on staff to assist nursing faculty with the development of multimedia to support learning.

Beyond providing a flexible method of delivery for instructional information, multimedia promise to accommodate different learning styles and motivate students by requiring them to analyze evidence in ways that require higher-order thinking and problem-solving skills.

Box 19-3 provides an overview of the capabilities of **smartphones** and their use in education.

BOX 19-3 SMARTPHONES AND OTHER SMART DEVICES IN NURSING EDUCATION

Smartphones are another tool for the educational arena. As Yu (2012) stated, "Smart phone technology, with its pervasive acceptance and powerful functionality, is inevitably changing peoples' behaviors" (para. 6). According to Georgiev (2023), the following are the current statistics concerning smartphone usage: Worldwide 2.71 billion people use smartphones, 81% of Americans own a smartphone, more than 285 million people in the United States with 94% of people aged 18 to 29 and 98% of Gen Zs. Nursing educators' use of a technology, such as smartphones, not only affects the learning episode but also influences how students are prepared to embrace and use technologies appropriately. They want their students to remain competitive in a highly technologically dependent world. Nursing is a data- and information-driven profession, and nurses must rely on technology to provide the data and information necessary to provide safe and high-quality care to their patients.

If students have smartphones, nursing educators can share text; graphics, such as PowerPoint presentations; podcasts; and other audio and video media with them prior to the learning episode. When all students have access to the

same information, the dialogue and topical discussion centered on that information are enhanced. Nursing educators can use smartphones to distribute announcements, reminders, and even pertinent notes that the students need. Students can also be polled using these devices. Smartphones can even replace huge textbooks with electronic files. Smart devices and their calendars and messaging features help both educators and students organize their lives and keep their hectic schedules straight. The use of smart technology can facilitate interactions around the world. Students can consult with other students and experts from anywhere on the globe. As this brief list of applications suggests, educators continually think of ways in which to incorporate smartphones into their learning episodes.

In conclusion, we would like to leave you thinking about a money-saving alternative for many schools. Instead of requiring a laptop computer, what if your school required every student to have a smartphone? Could we replace the expensive computer labs on our campuses while better connecting our online and blended students to their educational milieu?

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Promoting Active and Collaborative Learning

Because of the shift within the teaching–learning context from the individual seeking answers to the group trying to construct new knowledge from available information, the most effective learning solutions require new digital communication skills, new paradigms, new pedagogies, and new practices. A collaborative, student-centered approach uses the best tenets of inductive teaching by imposing more responsibility on students for their own learning than is assumed in the traditional lecture-based deductive approach. These constructivist methods are built on the widely accepted principle that students are constantly constructing their own realities rather than simply absorbing versions presented by their teachers. Collaborative methods often involve students' discussion of questions and in-class problem-solving, with much of the work (in and out of class) done by students in groups rather than individually (Felder & Prince, 2007).

Johnson and Johnson (1990) identified five significant elements for successful collaborative learning that are still pertinent today:

1. Face-to-face interaction between students, allowing them to build on one another's strengths
2. Mutual learning goals, which in turn prompt students to exhibit positive interdependence rather than individualized competition
3. Equal participation in the work process and personal accountability for the work one contributes
4. Regular debriefing sessions as a group after meetings or presentations, during which time feedback is shared and observations are analyzed
5. Use of cooperative group process skills learned in the classroom

Although collaborative learning relies heavily on student investment and participation, institutions must ultimately create the best physical, electronic, and immersive settings in which

collaboration is encouraged. Creating these settings can be achieved with a sound educational and technological infrastructure, reliance on proven working models, adaptable physical spaces, and even pedagogical support in the form of preceptors or mentors.

Especially useful for nursing students is the collaborative fieldwork model in which two or more students share a clinical setting and the same fieldwork educator. In this model, learning happens in a reciprocal fashion, with students constructing knowledge by watching each other and exchanging ideas. The most effective fieldwork experiences are highly structured with clear outlines of responsibilities, duties, and expectations to ensure that the experience matches the learner's expectations. The sharing of perspectives and viewpoints results in the generation of new knowledge and the restructuring or reorganization of existing knowledge. All activities performed by students, such as conducting evaluations, are done jointly so that peers provide each other with objective feedback, which eventually leads to increased self-confidence (Costa, 2007).

Libraries have also begun to recognize their role in students' success with and predisposition toward collaborative learning by creating redesigned spaces that reflect students' need to huddle in small groups; sit closely together without barriers; chat about their work; and view digital information without physical hindrances, such as carrels or work stalls. A leader in this movement has been Indiana State University, whose information commons features completely overhauled furniture, software, monitors, processing power, and wireless access to the university's network. Students can now collect as a group at kidney-shaped tables; better see the information loaded on the flat-screen monitors; make use of brainstorming, design, and planning software; and discuss their work in a chat-friendly zone. Some faculty members have even scheduled classes at the learning stations, and students, including those in nursing, have responded enthusiastically to the evolved space (Gabbard et al., 2007).

In addition to adaptable physical spaces that encourage discussion and group work, students require a supportive infrastructure that

provides the essential elements for successful research and scholarship. These elements include professional development support in the form of workshops that help students acquire or refresh skill sets; presentation opportunities; and hardware, software, and resource support. One such example involves the participation by nursing students at the University of Texas Medical Branch School of Nursing in the Scholarly Talk About Research Series (STARS), in which students and faculty give presentations of their work before presenting those materials at professional conferences (Froman et al., 2003), thereby eliciting collegial feedback, collaborative troubleshooting, and shared research ideas. Imagine how powerful such a process would be in a cross-discipline healthcare education school.

Simply adopting a collaborative, inductive method of learning, however, will not necessarily lead to better learning and more satisfied students. As with any form of instruction, collaborative teaching methods need skilled and careful implementation. Because students can be resistant to instruction that makes them more responsible for their own learning, those who attempt to implement an inductive learning method should adhere to best practices, such as providing adequate scaffolding, which is extensive support and guidance when students are first introduced to the method and gradual withdrawal of that support as students gain more experience and confidence in its use (Felder & Prince, 2007).

Nursing preceptors and mentors, for example, can provide this kind of scaffolded support as clinically active role models (Armitage & Burnard, 1991) and problem-solving **advocates** and collaborators (Gagen & Bowie, 2005). As individuals who are primarily concerned with the teaching and learning aspects of the relationship, preceptors help students learn by acting as clinical practitioner role models from whom the students can copy appropriate skills and behaviors. Kramer (1974) introduced the concept of nurse preceptor to address the theory and practice gap, which is the difference between what is taught in class and what actually happens in nursing practice. Preceptors enhance clinical competence through direct role modeling, which is especially valuable in a field where

competence and clinical ability are paramount (Armitage & Burnard, 1991). Mentors, who are similar to preceptors, provide equally valuable assistance to nursing students in the form of a facilitator. Mentors are most often used in nursing and education to support new professionals who are trying to fulfill the rigors of a new position while negotiating the stress inherent to a new environment (Gagen & Bowie, 2005). According to Jokelainen et al. (2011), "student mentoring in nursing clinical placements integrates environmental, collegial, pedagogical and clinical attributes" (para. 6). Mentors tend to address student needs through open conversation, student advocacy, feedback on student progress, facilitation, teaching, and general support (Neary, 2000). **Artificial intelligence (AI)** agents are also available to students to support them throughout their educational programming.

Generally, these and other forms of institutional support promote students' adoption of a meaning-oriented approach to learning, as opposed to a surface or memorization-intensive approach. Collaborative, inductive learning promotes intellectual development that challenges the dualistic thinking that characterizes many entering college students, which holds that all knowledge is certain, professors have it, and the task of students is to absorb and repeat it (Felder & Prince, 2007, p. 55). Further, this kind of learning helps students acquire the self-directed learning and critical thinking skills that characterize the best scientists and engineers (Felder & Prince, 2007). The active, engaging elements of collaborative learning increase self-confidence, promote autonomy in students, and foster a commitment to lifelong learning (Costa, 2007), all of which are necessities for the success of a new millennial information-literate student.

APPLICATION OF AI TO NURSING EDUCATION: INTELLIGENT VIRTUAL ASSISTANTS FOR STUDENTS

The intelligent virtual assistant for students is powered by AI. AI agents have the ability to learn based on their foundational core of algorithms or sequential instructions that ensure a particular task completion. The algorithms become a set of well-constructed rules that help the AI agent learn on its own. The pillar of AI is built by putting algorithms together in a layered approach.

The AI agent can help students with the following:

- Student services
- Campus life
- Extracurricular school activities
- Class and clinical activities and assignments
- How to study
- Library access and help
- Locating, organizing, and learning from their educational materials
- Tracking progress on assignments and due dates
- Creating their e-portfolios
- Learning how they learn, to present material and pace learning based on their needs
- Motivating them

As more nursing programs are implementing AI agents, they are refining what they can do for their students and how they can enhance the student experience. Just as we have seen increased satisfaction from patients when they have access to intelligent virtual assistants, we are seeing the same reaction from students who receive immediate help, feedback, and encouragement. "Learners who receive feedback immediately show greater improvement" (Jones, 2020, para. 8).

AI can affect how we interact with learning tools and information while facilitating and directing individualized learning through adaptive learning and serious games and providing the ability for students to work at their own pace. The AI agent could act as a tutor to help students achieve higher-order thinking. AI is being used to support the development of critical thinking, clinical judgment skills, and clinical competence, and therefore it positively affects the nursing process, patient care, and patient safety.

The idea behind and motivation for using AI is to drive positive educational outcomes while improving the student experience and enhancing student satisfaction. As you think about AI, reflect on the following quote, which depicts the challenge of humanizing AI to optimize the results: "The future will be about pairing the artificial intelligence of computers with the cognitive, social and emotional capabilities of humans, so that we educate first-class humans, not second-class robots" (Organisation for Economic Co-operation and Development, 2019, para. 3).

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ARTIFICIAL INTELLIGENCE (AI)

At the end of November 2022, OpenAI released ChatGPT. OpenAI (2023) stated that they have "trained a model called ChatGPT which interacts in a conversational way. The dialogue format makes it possible for ChatGPT to answer follow-up questions, admit its mistakes, challenge incorrect premises, and reject inappropriate requests" (para. 1).

Learning was truly disrupted by AI in the beginning of 2023 when the AI capabilities of ChatGPT exploded onto the education scene. Students were experimenting with its use, and educational administrators and faculty were and still are scrambling to decide their response to ChatGPT use by learners. Some faculty have banned its use in their courses, others are waiting for program- or university-level decisions to be made, while still others have accepted its use under certain circumstances. One faculty member shared that they would allow it to be used if the student acknowledged how much of the assignment or discussion response was generated by ChatGPT, what they asked ChatGPT, and what they edited and added. Other faculty want ways to know that ChatGPT actually did the work. To that end, OpenAI created and released a tool to detect human writing from AI-generated text, even from ChatGPT (Wiggers, 2023). In addition, Turnitin also provided a sneak peek at its AI-detection capability, which is even able to detect ChatGPT (Chechitelli, 2023). We are seeing more AI tools being released along with those that can detect their use. Expect to see AI capabilities expanding rapidly. Academic units and faculty must work to harness and leverage the use of AI within their rules of use for their students. To test ChatGPT's capabilities, Dr. McGonigle accessed ChatGPT, and their interaction is shared in **Table 19-1**.

TABLE 19-1 ChatGPT Responds to Dr. McGonigle's Queries

Dr. McGonigle's Query	ChatGPT's Response
What is AI?	AI (artificial intelligence) refers to the simulation of human intelligence in computers and machines. It involves developing algorithms and statistical models that enable computers to perform tasks that typically require human cognition, such as understanding natural language, recognizing objects in images, and making decisions. The goal of AI is to create systems that can perform these tasks as accurately and efficiently as possible, approaching or even surpassing human ability in some cases. AI technologies such as machine learning and deep learning allow computers to learn from data and improve their performance over time, leading to many exciting new applications in various fields.
Describe AI.	AI (artificial intelligence) refers to the simulation of human intelligence in machines that are designed to think and act like humans. This can be achieved through a variety of techniques such as machine learning, deep learning, natural language processing, and computer vision. The goal of AI is to create systems that can perform tasks that typically require human intelligence, such as recognizing images, understanding natural language, and making decisions. AI has the potential to revolutionize many industries, including health care, finance, education, and transportation, by automating repetitive tasks, improving efficiency, and enabling new and innovative applications. However, there are also concerns about the ethical and societal implications of AI, such as job displacement, biased algorithms, and privacy concerns.
How can faculty members leverage, harness, and	Faculty members can leverage, harness, and control AI (artificial intelligence) use in their courses in several ways:

Dr. McGonigle's Query	ChatGPT's Response
control AI use in their courses?	1. Incorporating AI technology into course material: AI can be used to enhance the teaching and learning experience in a variety of ways, such as using chatbots for answering student questions, using AI-powered tutors for personalized instruction, and using machine learning to analyze student performance data. 2. Developing critical thinking skills: Incorporating discussions and activities that challenge students to think critically about AI, its impact on society, and its limitations can help students understand the implications of using AI and develop their own ethical framework. 3. Establishing guidelines and policies: Faculty members can establish clear guidelines and policies for using AI in their courses, such as guidelines for ethical use and data privacy and policies for student data management. 4. Staying current: Staying up to date with AI advancements and best practices for incorporating AI into teaching and learning can help faculty members stay ahead of the curve and effectively leverage AI in their courses. By leveraging and harnessing AI, faculty members can create a more dynamic and engaging learning environment while still maintaining control and ensuring ethical and responsible use of AI technology in the classroom.
How is AI being used in health care?	Artificial intelligence (AI) is being used in health care in a variety of ways to improve patient outcomes, streamline processes, and increase efficiency. Some examples of AI applications in health care include: 1. Diagnosis and treatment planning: AI-powered tools are being used to analyze medical images,

Dr. McGonigle's Query	ChatGPT's Response
	such as X-rays and MRIs, and to provide more accurate diagnoses and treatment plans. 2. Predictive analytics: AI algorithms can analyze large amounts of patient data to identify trends and predict outcomes, enabling healthcare providers to make more informed decisions and improve patient care. 3. Chatbots and virtual assistants: AI-powered chatbots and virtual assistants are being used to provide 24/7 patient support, answer questions, and schedule appointments. 4. Drug discovery and development: AI algorithms can analyze vast amounts of data and help identify new targets for drug development, speed up the discovery process, and reduce the time and cost of bringing new drugs to market. 5. Clinical decision support: AI algorithms are being integrated into electronic health records (EHRs) to provide real-time decision support to healthcare providers, reducing the risk of medical errors and improving patient outcomes. By leveraging AI, healthcare organizations can improve patient outcomes, streamline processes, and increase efficiency while reducing costs and improving patient satisfaction. However, it's important to note that AI in health care is still in its early stages and further development and testing are needed before widespread implementation.
How would you describe ChatGPT?	ChatGPT is an AI-powered language model developed by OpenAI, capable of generating humanlike text based on input prompts. It uses deep learning algorithms and a massive amount of text data to generate responses to questions, carry out conversations, summarize long articles, and perform

Dr. McGonigle's Query	ChatGPT's Response
What are the benefits, weaknesses, and concerns about using ChatGPT as a student?	various other language-related tasks with high accuracy. Benefits: * Can save time by quickly providing relevant information on a wide range of topics * Can help with writing and language-related tasks by suggesting text completions, proofreading, and providing writing suggestions * Can improve language skills by exposing users to diverse writing styles and ways of expressing ideas Weaknesses: * Does not always provide accurate or reliable information, especially when it comes to subjective or opinion-based questions * Cannot replace human interaction or creativity in some areas such as personal expression, critical thinking, and problem-solving * Potential ethical concerns, including the role of AI in shaping human thoughts and behaviors Concerns: * The use of language models like ChatGPT raises questions about the reliability and trustworthiness of information generated by AI. * There are also privacy and security concerns around the vast amount of data these models collect and the potential misuse of such data. It's important for students to be critical and evaluate the information provided by ChatGPT and use it as a starting point for their own research and learning rather than relying solely on the information it provides.

ChatGPT has the capability to write a paper or an article, craft a response to a discussion question, and even build a course. Refer to Chapter 25, *Our Expanding Realities and the Metaverse,* to see what ChatGPT generated about the metaverse.

Reflect on the ethical concerns of using AI. Please review the Ethical AI Database (2023) report on the state of the ethical AI ecosystem at www.eaidb.org/reports/2023H1.

Note that there are also AI image generators that translate text into beautiful images. This eruption of AI into our professional and personal lives is just beginning.

Knowledge Dissemination and Sharing

Sharing stories and experience from a clinical point of view accomplishes much more than simply promoting camaraderie or empathy (although this kind of engagement is infinitely valuable in its own way); sharing experiences of clinical learning can help convey lifesaving information to other clinicians in a way that is more memorable and palatable and less imposing than warnings delivered outside a social context. Clinical and caring knowledge, often rooted in everyday exchanges, becomes socially embedded such that those with experience in particular clinical settings share common knowledge and understanding. The social embeddedness of caring and clinical knowledge is a result of shared and shaped collective understanding of practice and sometimes provides an alternative view.

The power of pooled knowledge in combination with knowledge produced in dialogue with others helps to limit tunnel vision and is a powerful strategy for maximizing the clinical knowledge of a group. Whether the nurse is networking, presenting, or seeking continuing education or recertification, an understanding of socially embedded knowledge coupled with the multiple perspectives of skilled practitioners allows for a rich and vibrant opportunity to apply nursing skills effectively (Benner et al., 1997).

Networking

Considered crucial to career development because of opportunities for collaboration and information exchange, networking encourages professional support by making successful professionals accessible to their colleagues. Further, developing interactive professional networks between academic and clinical nurses can benefit practice in diabetes, stroke, and mental health care and community nursing—the latter being a field in which practitioners are encouraged to collaborate (Gillibrand et al., 2002).

The value of networking to members of male-dominated professions, such as law, business, and medicine, resides in opportunities to make contact with fellow professionals and in turn further one's career. This observation is especially poignant for nursing, a predominantly female profession.

Because nurses tend to gather their information from personal networks, such as colleagues or professional meetings, the increased availability of technology to assist in networking has greatly facilitated information exchange. Blogs, email, websites, electronic mailing lists, and other communicative technologies have opened an endless stream of collaboration and networking possibilities, which has allowed nurses to more easily access and learn from colleagues' experiences. Using the internet allows for the discovery of information heretofore unavailable through traditional information sources (Pravikoff & Levy, 2006), which helps nursing professionals decide whether, for example, pursuing research opportunities or collaboration on specific professional projects seems viable.

A formal network such as the ICN Nurse Practitioner/Advanced Practice Nurse Network (INP/APNN), unveiled in 2000, promotes the exchange of knowledge, resources, and expertise to enhance the presence of nursing in primary health care. Created in response to the globalization of nurse practitioner and advanced practice nursing network roles, the network enables the enhancement and advancement of practice for countries just beginning to initiate advanced practice nursing roles.

Membership and participation in professional associations also provide ways to network and advance one's profession. Professional associations represent venues through which members may set standards for professional practice, establish codes of ethics, become involved in advocacy, engage in continuing education opportunities, access job banks, subscribe to professional journals, and act as a common voice for the profession. For example, the American Association of Occupational Health Nurses is instrumental in maintaining healthcare issues on the political agenda. There are also several opportunities for nurses to network in specific informatics associations, such as the American Nursing Informatics

Association and the nursing work group associated with HIMSS. Research shows that sometimes nurses hesitate to join professional organizations because of barriers associated with cost, distance to meetings, lack of activities in their geographic area, and inability to attend meetings. Because networking creates fertile areas for the development of new ideas, partnerships, jobs, and strategies, both national and state associations would benefit from creating greater opportunities for healthcare practitioners to earn continuing education credits and network with others in their field.

Presenting and Publishing

Just as the AACN maintains standards for nursing education, so too do professional journals hold their contributors to rigorous standards and provide a valuable venue in which nursing professionals might share ideology and innovations in the field. With the proliferation of online journals and the availability of nursing information via multiple media, publishing remains an excellent way to participate in the dissemination of professional information. Both nursing magazines and journals reach considerable audiences; journal distinctions lie in their authorship and audience. Although journal articles are written by and for scholars, with refereed or peer-reviewed journals requiring a blind review by a group of reviewers to eliminate bias, magazine articles may be written by a professional in the field, an editor, a freelancer, or some other author. Publishing provides excellent opportunities to extend knowledge and share research. The scholarly, peer-reviewed *Online Journal of Nursing Informatics* (*OJNI*) was the first online nursing informatics journal cofounded by Dr. Dee McGonigle and Dr. Renee Eggers in 1996 and transferred to HIMSS leadership in 2013.

Like publishing, making presentations at contemporary professional conferences allows nursing educators and students to gain experience and share scholarship with colleagues. Presentations must meet certain standards for an audience to find them credible and effective. Because audience members retain 50% of what they

see and hear in a presentation versus 20% if they only hear it, experts suggest the use of audiovisual aids to create the most effective professional presentations (Bergren, 2000). A noteworthy presentation could involve multiple levels of complexity, from a simple PowerPoint slide to an animated tutorial. Because technology and well-designed visuals cannot make up for lack of preparedness or research, however, presenters should be aware of their target audience and the details of the research being presented. Regardless of the medium or presentation style, audiovisual presentations should be designed consistently and simply, using colors and fonts that are easy to read and understand and audience-appropriate language.

Conferences often host poster presentations, which enable contributors to share research findings, innovations, and exemplar programs in a low-investment but visually captivating way. Because posters are primarily visual, with little or no verbal supplementation, most important for consideration are room elements, such as size, space limitations, and lighting. The best nursing practitioner posters feature consistent visual components, such as appropriately sized, readable font and simple colors, and are based on a research concept or clinical objective (Berg, 2005). A high-tech alternative to a paper poster is an electronic poster, which is a continuously running PowerPoint presentation either projected for larger audiences or left to run from a laptop or desktop computer for smaller audiences (Bergren, 2000). Both publishing and presenting provide opportunities for the nursing practitioner to disseminate new knowledge and stay abreast of information in the field. Some educational institutions provide opportunities for undergraduates to showcase projects and research at undergraduate research conferences. These conferences are excellent ways for developing professionals to hone knowledge dissemination skills that will serve them well in their professional practice.

Continuing Education and Recertification

Nationally, nursing employers and institutions have, because of budgetary constraints, begun to eliminate **continuing education (CE)** programs traditionally reliant on classes, conferences, and workshops; consequently, reliance on outside agencies and technology has increased to meet this need. The traditional approach to obtaining CE credits has included home study offered by professional journals and organizations in which the client reads articles, answers related questions, and sends in the test form and fee. With the ubiquitous technology influx and the accessibility it affords, obtaining CE credits through e-learning is considered a beneficial delivery method for mandatory educational programs and other programs that provide employees with opportunities to maintain or improve skills. Benefits of e-learning for CE training include the ability to access information at any time (thus creating a flexible schedule) and experience instant feedback and individualized instruction by seeking out specific, additional information as needed.

E-learning can also benefit administrative support of CE credits by providing instantly accessible computerized records and other tracking features, such as records of success and completion, associated costs of program development, and staff productivity. Allowing nursing professionals to complete mandatory training on demand represents a huge benefit of e-learning.

In some cases, acquiring CE credits may also help the nurse achieve recertification. Available through myriad professional organizations, recertification ensures that nurses are staying current in their fields and some specialties; for example, the field of pediatric nursing requires annual recertification to maintain professional status. During recertification, the Pediatric Nursing and Certification Board offers each certified pediatric nurse options for ensuring that they are maintaining national standards within the specialty of pediatric nursing (Pediatric Nursing Certification Board, n.d.).

As an added benefit, some hospitals provide higher salaries to nurses who maintain certification. In addition, 90% of nurse managers indicate that they would prefer to hire a certified over a noncertified nurse. The trend in Magnet hospitals to encourage, reward, and promote certified nurses is spreading to other facilities

and healthcare settings, with retirement centers and home health agencies now beginning to seek certified nurses because of the perceived extra benefit to their customers and the marketing advantage obtained from hiring nurses with guaranteed levels of competence (Peterson, 2007). For a comprehensive list of nursing certifications provided by the American Nurses Credentialing Center, visit www.nursingworld.org/ancc.

Exploring Information Fair Use and Copyright Restrictions

As we adopt more technology-based tools in education, we need to be mindful of what constitutes fair use of materials and copyright laws. Nurse educators should be careful to model ethical behaviors by attributing works to their rightful authors as they acquire and use education materials. **Fair use** refers to a legal concept that permits the use of copyrighted works for specific purposes without obtaining permission from the author or paying for the use of the work. Originally, fair use evolved for written work and allowed for uses that include journalists' reporting the news, teaching, or scholarly research. As digital technology and the web burst upon the scene, fair use expanded to apply to the copying and redistribution of digital media, including photographs, graphics, music, videos, audio, and software or computer programs.

Four factors must be considered in determining whether a particular use is fair. These factors are derived directly from the fair use provision (www.copyright.gov/title17/92chap1.html#107) of Section 107 of the U.S. Copyright Law (U.S. Copyright Office, n.d.):

1. The purpose and character of the use, including whether such use is of commercial nature or is for nonprofit educational purposes
2. The nature of the copyrighted work
3. The amount and substantiality of the portion used in relation to the copyrighted work as a whole
4. The effect of the use upon the potential market for, or value of, the copyrighted work

The first factor tends to favor educational institutions and nonprofit entities. The second factor relates to the nature of the work; courts have consistently protected creative works and those that have not yet been published. The third factor that must be

considered relates to the amount of use. Typically, you should determine how much of the overall work you are using; if it represents the core, or essence, of the work, you should not replicate or use it. The fourth and final factor relates to the effect on the creator's market share. If you are using a substantial portion of a text or software work that is offered for sale, you can adversely affect its owner's earning potential. The term itself should make you reflect on all these factors and decide whether your proposed use is fair.

Copyright refers to the exclusive right of the creator of a work to distribute, sell, publish, copy, lease, or display that work in whatever manner they choose. Copyright laws are not only misinterpreted but also are constantly being challenged by our advancing technological capabilities. Think about AI and ChatGPT. Who owns the content AI generates? How should we cite it? Even though you use American Psychological Association formatting, for example, and cite the authors, you might be overstepping your rights and infringing on the author's copyright; you might not be accused of plagiarism, but you should always cite where you obtained your information or digital media.

All users of others' work, in whatever medium, must fully understand, be aware of, and comply with copyright and fair use principles. Typically, you should try to think of what reasonable use is and always make sure that you cite the authors. Reflect on all four fair use factors before making your decision to use another's work for educational purposes. Also, remember that you are serving as a role model regarding copyright and fair use behaviors for your students.

The Future

There are several exciting and interesting education technology trends to monitor in the future. Virtual reality–embedded education has exploded onto the academic scene and offers the potential for interdisciplinary inquiry and sharing across the curriculum and university and globally. Makerspaces are labs provided on university campuses (and in some healthcare institutions) to allow students and healthcare workers to experiment with developing new technologies or modifying existing technologies and equipment to better fit needs. These spaces are frequently equipped with three-dimensional printers and lots of tools and materials that allow for rapid prototyping of ideas.

Several universities around the country, such as the University of South Florida, University of Pittsburgh, Yale University, and Arizona State University, are sponsoring healthcare innovation competitions. Other universities are partnering with industry leaders to sponsor student ideas for healthcare innovations. The Internet of Everything (IoE), which is another trend, is touted as the next step beyond the connections of physical things (Internet of Things, or IoT):

> *IoT focuses only on sensor networks—machines communicating with other machines, and the data created as a result. As things add capabilities (such as context-awareness, increased processing power, and energy independence), and as more people and new information are connected, IoT becomes IoE, a network of networks where billions, or even trillions, of connections create unprecedented opportunities and new risks.* (Sepulveda Galvis, 2013, p. 3)

Education innovations related to the IoE hold promise for improving education processes, outcomes, and instruction. For example, mobile devices and wearables allow for the collection of learner behaviors, and these data can be translated into targeted, personalized learning. Data generated from the IoE may also be used for professional development to improve teaching and

curricular approaches and effectiveness. These are but a few of the education technology trends to watch for in the future.

Summary

This chapter highlighted the technology tools and delivery modalities that support nursing education. Nursing education is evolving and will be structured by competency achievement and supported by technologies. In an ideal world, nurses would work against the assumption that technology runs itself and take proactive roles in helping to design the education and technologies necessary to best prepare them for real-world scenarios. Consider that flash is not substance and drama is not depth; technology performs only as well as the pedagogy that undergirds and sustains it. Plan for and use technology with care so that its best features consequently enrich your experiences as an educator or a learner.

THOUGHT-PROVOKING QUESTIONS

1. What are some of the forces behind the push toward a more wired learning experience in nursing education?
2. Which of the technologies discussed here most appeals to you? Why?
3. Explore one of the newer learning technologies in more depth. How would the use of this technology benefit you in your practice or education setting? Why do you find this tool useful? From your perspective, how could you enhance this tool?
4. Jean, a diabetes nurse educator, recently read an article in an online journal that she accessed through her health agency's database subscription. The article provided a comprehensive checklist for managing diabetes in older adults, which Jean prints out and distributes to her patients in a diabetes education class. Does this constitute fair use, or is it a copyright violation? Explain your answer.
5. Reflect on your thoughts about ChatGPT. In detail, describe your perspective about its use:
    1. by students,
    2. in relation to copyright, and
    3. by faculty.

6. Describe Generation Z in detail in relation to nursing education. How would a Generation Z student have handled the dissemination of the article in question number 4? Provide a detailed rationale for your Generation Z approach.

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CHAPTER 20

Simulation, Game Mechanics, Virtual Worlds, and the Realities in Nursing Education

OBJECTIVES

1. Distinguish among learning environments as simulations, virtual worlds, or games.
2. Describe the role of simulation in nursing informatics education.
3. Compare and contrast simulations, virtual worlds, and games as informatics tools for nursing education.
4. Assess strategies for choosing among a simulation, virtual world, or game as the best choice for instructional delivery in a given educational situation.
5. Explore the role of simulation, virtual worlds, and games in nursing education.
6. Differentiate between using a live clinical information system or simulated electronic health records for educational purposes.
7. Assess the realities of augmented reality and virtual reality in relation to nursing education currently and within the foreseeable future.

KEY TERMS

- academic electronic medical record (AEMR)
- assessment

- augmented reality (AR)
- augmented-reality game (ARG)
- avatar
- clinical information system
- database
- debrief
- dynamic web page shell
- edutainment
- enactment
- engage
- feedback
- fidelity
- game
- game mechanics
- gameplay
- immersive experience
- latex-based simulation
- massive multiplayer online role-playing game
- massive open online course (MOOC)
- Multimedia Educational Resource for Learning and Online Teaching (MERLOT)
- multiuser dungeon
- nonplayer character (NPC)
- object-oriented multiuser dungeon
- prebrief
- prebrief, enactment, debrief, and assessment (PEDA)
- reusable learning object (RLO)
- scaffolding
- Second Life (SL)
- serious game
- server
- simulated documentation
- simulation
- simulation scenario
- simulator
- three-dimensional (3D)

- virtual reality (VR)
- virtual simulation
- virtual world

Introduction

The use of latex-based and virtual simulation (**Figure 20-1**), **virtual worlds**, and game mechanics in nursing education was increasing, but with the COVID-19 pandemic, their integration really escalated to meet the needs of students who could not attend clinical experiences or classes. Many schools and staff education departments have employed these techniques to provide efficient, effective, and engaging educational experiences for their students and staff. The schools and other educational entities began realizing the benefits of these educational modalities. The monumental National Council of State Boards of Nursing (NCSBN; Hayden et al., 2014) simulation study brought national attention to the need to enhance, extend, or replace clinical and practicum hours with other effective means, such as simulation. In this chapter, we will explore simulated documentation, simulation, virtual worlds, and game mechanics used in teaching nursing informatics competencies and nursing education.



Figure 20-1 Latex-Based Simulation

Even though there are many nursing students, nursing educators, and nurses using these technologies, no clear understanding of the terminology associated with these learning modalities exists. Therefore, it is important to define this terminology when discussing these technologies and their effect on nursing informatics and nursing education.

- **Simulations** are imitations of real-life events or circumstances; in nursing education, simulations are used to replicate a clinical scenario to provide an opportunity for practice in a mock situation. These simulations can be done with mannequins (**latex-based simulation**) or via role-play, web-based applications, or **virtual simulation** in a virtual world.
- A **simulator** is a mechanical or electronic device that provides an environment in which a simulation can occur.

- **Simulated documentation** refers to any simulated electronic format or electronic health record (EHR) that is accessed and used by the learner to actually document simulated nursing care for educational purposes.
- A **simulation scenario** is a situation or case developed in a simulation setting to mimic an actual practice situation.
- A **game** is a structured activity undertaken for enjoyment.
- In education, **edutainment** is the combination of *education* and *entertainment* to make learning fun.
- **Game mechanics** are the rules, instructions, directions, and constructs that the learner interacts with while playing the game. For educators, it is essential that any game mechanics they use be engaging and satisfying for the learner.
- **Gameplay** is how the learner interacts with or plays the game. This is extremely important to understand to be able to appreciate how the game functions and the learners function, play, and learn.

As you progress through the chapter, you will delve into simulated documentation, simulation, game mechanics, virtual worlds, and the realities.

Examples of Simulation in Nursing Informatics Education

Following are two examples of using simulation in nursing informatics education. In the first example, the EHR is part of a larger simulation scenario that mimics a real-life clinical case, and in the second example, the EHR itself functions as a simulator and becomes a true-to-life learning tool.

In the first example, the patient call bell is ringing; you enter the room to find the patient verbalizing complaints of chest tightness. In a moment, the patient becomes unresponsive, and a code is called. The team quickly responds, initiating resuscitation measures per the advanced cardiac life support protocol. You review the EHRs with the attending physician while discussing your assessment before the code. After a short while, the resuscitation efforts are successful, and the patient is stable enough for transfer to the intensive care unit. You complete your documentation in the patient's EHR, the simulation scenario ends, and the debriefing begins. The instructor provides **feedback** not only on actions taken within the simulation scenario but also on the use of the EHR as an important resource for patient information and documentation.

In the second example, it is the first day of a new course, and rather than a lecture-based class with an accompanying textbook, the instructor uses an active learning approach with case studies delivered through an EHR interface to facilitate the learning and application of clinical concepts. In this example, rather than being part of an entire simulation scenario, the EHR itself is the learning tool providing learners with a hands-on learning opportunity centered on accessing and using the information contained within the patient record. Choi et al. (2016) concluded that **academic electronic medical records (AEMRs)** would improve students' understanding of clinical practice: "[T]he findings of this study will provide important developments by applying an AEMR, which will

augment students' informatics competencies and critical thinking, into the nursing curricula to better prepare the future workforce" (p. 264).

APPLICATIONS IN EDUCATION TO ENHANCE LEARNING

You are learning about informatics. What role or roles would the nurse informaticist assume in relation to each of these strategies? Reflect on nursing informatics' effect on each of the following instructional technologies and educational strategies described.

MASSIVE OPEN ONLINE COURSE

A **massive open online course (MOOC)** is a virtual or an online course with unlimited participation and open access via the web. The course runs over a set number of weeks using materials and resources available online. Some MOOCs have had up to 150,000 learners enroll, but most learners will not stay to complete the course. Murray (2019) reported "an astronomical dropout rate of about 96 percent on average" (para. 2). Traditionally, MOOCs are free and typically provide interactive opportunities using social media or other tools to support community interactions among learners and teachers. Learners select the courses they want to take and are in control since they set their own pace and attend or quit when they want. These factors place the responsibility of learning on the learner. "Much of the early enthusiasm for massive open online courses, or Moocs, focused on how they could disrupt and democratise education" (Murray, 2019, para. 1).

REUSABLE LEARNING OBJECT

A **reusable learning object (RLO)** is an approach to content development, consisting of independent, self-contained, digital, multimedia e-learning resources, that breaks the content into chunks so that each object can be swapped, interchanged, substituted, and exchanged as needed, based on the characteristics of the learners and their specific learning needs. Typically, RLOs contain a presentation, an activity, links and resources, and a self-assessment. They are based on the object-oriented model from computer science; this paradigm intends to assimilate the advantages of modules and seeks to recycle these objects as needed.

RLOs can be used repeatedly in a variety of learning episodes. Each RLO has its own learning objective and can stand alone, but when many RLOs are strategically combined, a comprehensive learning experience can be crafted. To facilitate the ability to plug and play, RLOs must be easily adaptable, interoperable with the infrastructure, and organized using targeted metadata so that they can readily be extracted for reuse. RLOs are little chunks of learning that provide the right amount of information needed to assist the learner in meeting a specific learning objective.

MULTIMEDIA EDUCATIONAL RESOURCE FOR LEARNING AND ONLINE TEACHING

Multimedia Educational Resource for Learning and Online Teaching (MERLOT) (www.merlot.org/merlot) is a web-based open resource that "provides access to curated online learning and support materials and content creation tools led by an international community of educators, learners, and researchers." It also includes an information technology community portal (www.merlot.org/merlot/InformationTechnology.htm).

ADAPTIVE LEARNING

Adaptive learning is an educational strategy that manipulates how the learning environment is displayed to the learner to allocate and mediate the learning resources, based on each learner's unique learning needs. The adaptive behaviors and activities are based on mathematical paradigms of knowledge and use artificial intelligence (AI) in an approach to actively tailor content to meet each learner's needs by adapting to the knowledge of the learner. This is a learner-centered approach because the learner's needs drive which educational episodes they are afforded.

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Nursing Informatics Competencies in Nursing Education

In the late 1990s, researchers identified that healthcare professionals needed to possess both skills in and knowledge of informatics (American Association of Colleges of Nursing, 1999; Gassert, 1998; Pew Health Professions Commission, 1998). In addition, information technology was identified as a key measure in improving patient safety and quality of care (American Academy of Nursing, 2003; Institute of Medicine, 2000). In response to the increasing demand for practitioners to become skilled in this area, coupled with the absence of research-based informatics competencies, a Delphi study was used to identify informatics competencies for nurses at four levels of practice (Staggers et al., 2002). In essence, this seminal study created informatics competencies for entry-level nurses through informatics specialists and innovators, with a focus on computer skills, informatics knowledge, and informatics skills.

Although informatics competencies for nurses have been identified, the degree to which schools of nursing have woven them into the curriculum varies greatly (Carty & Ong, 2006). In a study conducted by Fetter (2009), a survey of graduating senior nursing students ranked the following competencies with which they had no experience or minimal skill: (1) using applications to document, (2) creating an electronic care plan, (3) valuing informatics knowledge for practice, (4) valuing informatics knowledge for skill development, and (5) using applications for data entry. Hunter et al. (2013) developed an online self-assessment tool, the TIGER-Based Assessment of Nursing Informatics Competencies (TANIC); this instrument assesses the Level 1 Beginning Nurse and Level 2 Experienced Nurse competencies. McGonigle et al. (2013) developed the Nursing Informatics Competency Assessment (NICA) for Level 3 Informatics Nurse Specialist and Level 4 Informatics Innovator,

based on the seminal work of Staggers, the current literature, and expert input. This online self-assessment was noted in the 2014 American Nurses Association *Nursing Informatics: Scope and Standards of Practice, Second Edition*. These self-assessment tools are discussed in Chapter 7, *Nursing Informatics as a Specialty*.

The question then becomes, Which best practices will ensure that students become prepared in informatics? The National League for Nursing (2015) realized the need to prepare students for the technology-rich healthcare environments. Nursing educators and administrators indicated the need to make sure that informatics is integrated throughout the curriculum and that experience with nursing informatics is provided during clinical rotations as well. Little clinically related informatics content and few such learning experiences were provided in nursing programs. Technology tools containing care planning software and **clinical information systems** were least likely to be incorporated into the courses, and the lack of these tools continues to be an issue. Another area of concern is the preparation of the nursing informatics faculty in the use of these tools. Rajalahti et al. (2014) made several recommendations about competencies, including the following: "A description of nursing informatics competencies for nurse educators is needed at a national and global level. Advanced nursing informatics programmes are needed in the nurse educators' training programme" (p. 64). Nursing faculty must be prepared to use these technologies. With emerging technologies in nursing and healthcare education, the use of these technologies, including simulation, to allow students to use informatics in an active manner and in an authentic and realistic learning context is one potential approach to remedying these shortcomings.

A Case for Simulation in Nursing Informatics Education and Nursing Education

A simulation recreates a real-life set of conditions or events with as much fidelity as possible (Alessi, 1988). Aldrich (2010) contended that simulations develop cognition (i.e., learning-to-know skills), ethics and roles (i.e., learning-to-be skills), and application capabilities (i.e., learning-to-do skills). Unlike games, however, simulations are not necessarily designed to be fun.

Simulations contain four major components: **prebrief, enactment, debrief, and assessment (PEDA)** (refer to **Table 20-1**). Every simulation should have these elements in order to prepare and assess students while also facilitating learning through doing and reflection. The most important translational PEDA components are the **prebrief** and **debrief**. It is imperative that learners know exactly what is expected and be prepared for the **enactment** in the prebriefing. When done well, debriefing helps learners reflect on the authentic experience and solidifies the learning by facilitating the transfer of theory and skills to their real practice setting. Graduate nursing education is an area that is expanding learners' simulated learning episodes. Woroch et al. (2018) described a drug-seeking telephone triage scenario simulation in which family nurse practitioner (FNP) students collaborated with psychiatric mental health nurse practitioner students. Robinson-Reilly et al. (2020) stated that "[s]imulated telehealth allows students to engage in a learning environment that closely reflects real-life experiences without posing a threat to either the student or the patient" (p. 49). Harris (2020) simulated lacerations, abscesses, and suspicious lesions with nurse practitioner students. Harris et al. (2016) believed that simulation could assist FNP students with their role transition from generalist to advanced practice by doing the following:

TABLE 20-1 Simulation PEDA

Each simulation must have four components:

1. Prebrief
2. Enactment
3. Debrief
4. Assessment

Prebrief	Students receive the simulation information, the goal, the educational outcomes, and the related course or program outcomes. The simulation should be explained and focused for students. They should know how to prepare for the activity and be told what is expected, provided with the background necessary to be able to fully enact their role in the activity, and given the specifics about how they will be assessed. They must also be provided with the time frame within which the simulation must be completed.
Enactment	The simulation area is prepared to facilitate the activity. Students enact the role assigned and complete their assigned activities during the established time frame.
Debrief	Debriefing is "a student-centered discussion during which the participants and observers reflect on performance during the scenario and make recommendations for future practice" (Mastrian et al., 2011, p. 351). The debriefing can be done one-on-one or with entire teams. Faculty can help students during and after their activities by focusing on breakdowns and areas of growth to hone future learning episodes (Tanner, 2006). Following the completion of each activity, it is important to do the following: * Answer students' questions. * Address students' perspectives, perceptions, and concerns. * Emphasize and reinforce specific learning outcomes. * Create authentic linkages to the real world. * Assess students' learning. What did they learn? * Validate what students learned.

	Ask the students to reflect on the simulation activity, both how they felt during the activity and how they feel now that the activity is completed.
	1. What did students enjoy the most and the least about the activity?
	2. What were students' perceptions regarding the activity?
	  * Can students describe the emotions they experienced while completing the activity?
	  * How do students describe the interpersonal interactions or the enactment of their role?
	3. What were the major points of the activity?
	4. Did students experience any problems that affected their ability to make the necessary decisions during the activity?
	  * How could you prevent these problems in the real world?
	  * If you could not prevent them, how could you avoid them in the real world?
	5. What did students learn?
	  * What did students learn that was new to them?
	  * Did things that students already know take on new meanings after the activity?
	  * Was there a specific aspect of the activity where students learned the most?
	  * Reflect on students' perceived learning and validate what they learned.
	6. Would students recommend any changes to enhance the activity? If yes, what changes, and how would each change enhance the activity?
	7. What will students take with them after having completed this activity?

Assessment	Students should be provided with a detailed explanation of how they will be assessed and graded, which relates to the goal; educational outcomes; and, if applicable, course or program outcomes. Detailed rubrics are recommended. The assessment process must be shared during the prebriefing. If the activity is not being graded, a self-assessment should be provided for students so that they know how to evaluate their own performance.

- "Allowing FNP students opportunities to gain confidence in a risk-free environment.
- Providing FNP students an entire comprehensive office-based or acute patient care experience.
- Reinforcing classroom content and bridging the theory to practice gap" (p. 14).

Simulations may be experiential and task based, in which the learner takes on a first-person role and executes a self-chosen series of decisions by manipulating the variables in the simulation toward a desired outcome (Aebersold & Tschannen, 2013; Gredler, 1996). Simulations may also be symbolic scenarios in which the learner directly manipulates variables, sees the results of changes, and then makes decisions on how to continue in the simulation. Spreadsheets are often used for this type of simulation. Symbolic simulations are good choices for discovering principles, misconceptions, and relationships and for fostering understanding, prediction, and solution development (Mastrian et al., 2011).

Simulations may use a process known as **scaffolding** (Jonassen, 1999; Podolefsky et al., 2013) to assist in acquiring the accepted level of proficiency. An example of scaffolding is when corrective feedback is initially used to correct user mistakes and ensure success and then the feedback fades away when it is no longer needed.

Medical simulations use realistic three-dimensional computer models of humans to investigate new medical possibilities and test assumptions (i.e., learning-to-know skills). Simulations of drawing blood and performing complex medical operations are used to teach learning-to-do skills.

In general terms, a simulator can perhaps best be described as a tool designed to emulate some aspect of the clinical practice environment, which may be focused on a single task or designed to mimic a complete patient care situation (Gaba & DeAnda, 1998). At its essence, it is any device that is used to create a realistic learning

experience for the learner but that removes the risk associated with learning during hands-on patient care. A simulator offers the unique ability to create a realistic learning environment that is safe, structured, and supportive for the learner (Bligh & Bleakley, 2006).

Simulators encompass a broad range of devices, such as partial task trainers (e.g., an IV insertion arm); screen-based simulations, including simulated EHRs, documentation, and environments that replicate a realistic patient-care area (virtual simulation); and complex computer-driven human–patient simulation mannequins (i.e., latex-based simulation). Web-based virtual standardized patients are also increasing in use. It is important to understand which of these products you are using, one in which you enter and interact in a virtual world, access a web-based product, or interact in a latex-based lab. Although each of these simulation modalities can be used alone, they can be powerful learning tools when used together to create a realistic patient care scenario. When designing simulation learning environments, "[i]nnovative educators design learning environments that encourage active engagement in the learning process. . . . Active engagement creates a personal connection with the learning experience and motivates the learner to take greater responsibility in the learning process" (Fisher, 2016, p. 9). According to Gaba (2004), the goal of simulation is a seamless immersion into the simulated practice environment during which learners are drawn into the reality of the environment or task at hand. Hertel and Millis (2002) noted that this is a cooperative process whereby learners come together in an authentic setting and begin to learn from one another. Darragh et al. (2016) recommended realistic scenarios that elicit autonomous problem-solving and decision-making to immerse and **engage** the participants in active learning and critical thinking (**Figure 20-2**).

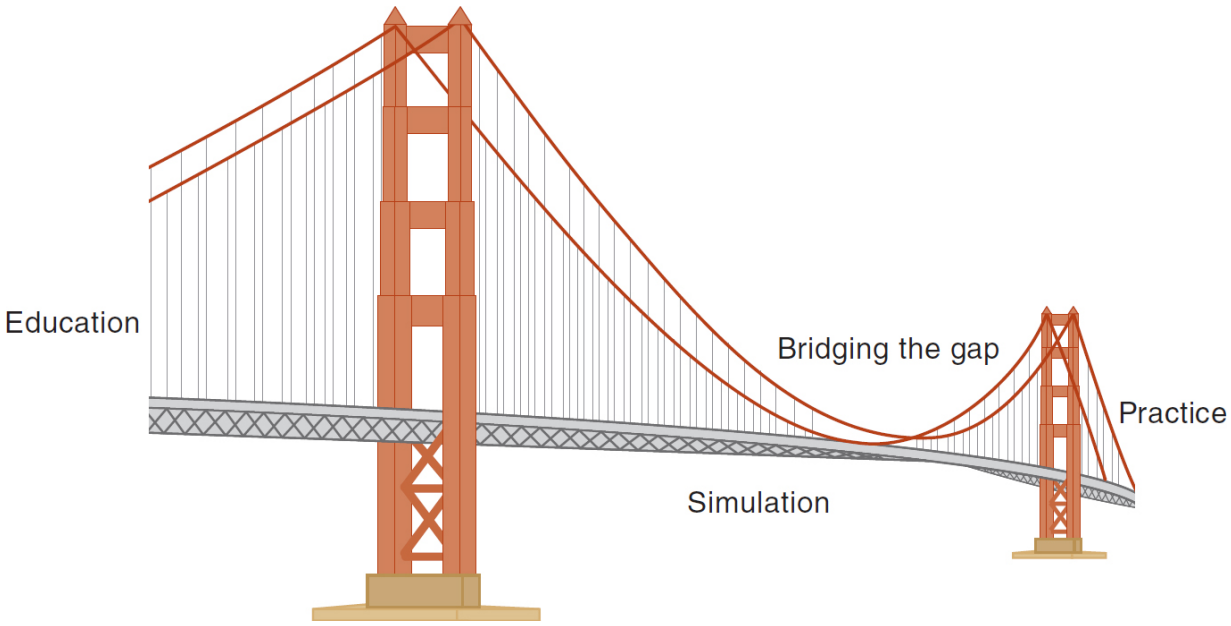


Figure 20-2 Simulation Can Bridge the Gap

Considering the realistic nature of simulation and its hands-on active approach to learning, it seems that the use of simulation modalities can be a powerful tool in moving student nurses—indeed, any practitioners—toward achieving the informatics competencies. Recall the examples given at the beginning of this chapter. In both examples, simulation is used to incorporate nursing informatics into the context of patient care, thereby giving students an authentic learning experience that can be applied in clinical practice.

According to the NCSBN national simulation study (Hayden et al., 2014), 50% simulation can be effectively used in various program types, in different geographic areas, and in urban and rural settings with good educational outcomes. The NCSBN study results and the lack of available quality clinical and practicum placements are prompting the move to integrate more simulation into nursing education. Virtual and latex-based simulations are valuable educational assets at all levels of nursing education. They provide a safe, authentic environment in which to develop knowledge, skills, and attitudes before interacting with actual patients. There is no risk to patients, and students can practice and receive **assessment** and feedback for controlled episodes, including unusual events.

Simulation relates well to adaptive learning methods, such as branching logic, that allow the learner to guide the learning. The nurse educator can tailor the simulation to the learning needs of the students and provide deliberate practice with feedback. The learner can learn, relearn, and hone skills while safely practicing in dynamic and complex situations with a view to decreasing and eliminating mistakes.

Incorporating EHRs Into the Learning Environment

There are two main approaches to the incorporation of an EHR into the learning environment, whether used within a simulated clinical environment as part of a patient care scenario or as a stand-alone learning tool. First, the EHR can be created specifically for simulation purposes; options range from a well-developed Microsoft Access database to commercially available products designed specifically for simulation purposes. Second, the simulation may use a real EHR system either within a hospital-based simulation center or through a partnership with a healthcare facility or an EHR vendor. Raths (2020) found that many health centers are using commercial EHRs.

There are certain advantages and disadvantages to each simulated documentation solution (**Figure 20-3**). Live documentation systems provide learners with a realistic experience and can be incorporated into the learning environment, but they also present certain drawbacks: (1) They are designed for the patient care environment, not the learning environment, and therefore lack an efficient feedback mechanism for learners; (2) they are designed to work in real time, not simulated time, which creates issues with data recall, especially when a record may be used repeatedly over a period of months or years; and (3) if a system is overly complex, it may unintentionally focus the learning on the specific system rather than on the process of data retrieval and documentation. Refer to Research Brief 1 for more on the challenges of teaching clinical documentation skills in an EHR.



Figure 20-3 Simulated Documentation Nurse/Patient. You are working as a team. This is Mr. Poli, and as your simulated patient, you will be saving him from falling when you assist him to the restroom and determining why he is unsteady. At the end of your shift, you will document the nursing care you provided to this patient. When you leave, Mr. Poli will tweet about his experience with each of you as his nurse and post comments about the care you provided. It is important to simulate not only what the nurse must document but also what the patients document and how they use social media to describe their care experience. It is important that you realize that patients take note of your actions and use social media to share their opinions and observations. Think about your best and worst experiences in health care. They might be something you experienced yourself or with a loved one. Where and what would you share through social media?

One system designed specifically for simulation is the web-based medical chart (WMC). This system requires four components: (1) a **database**, (2) **dynamic web page shells**, (3) a **server**, and (4) computers with access to the internet. With this system, a Microsoft Access database is created to hold administrative information about

the simulation scenario and other pertinent overview information accessible by only the instructor and the simulated patient data, simulated patient documentation, student documentation entries, and learner feedback from instructors. Each time a learner logs in to the WMC system via the internet, the server custom creates the requested page using the existing database information, user-specific information, and web page shells to create a realistic EHR for use by the student. Although this type of system offers a great deal of flexibility because it is custom created by the end user (and is certainly a cost-effective solution), it requires that the simulation instructor have a strong background in computer science and information technology to create and maintain the database and supporting materials.

RESEARCH BRIEF 1

Faculty perceptions of the challenges of teaching undergraduate students proper clinical documentation in both paper-based and electronic systems are described in a qualitative research study by Mahon et al. (2010). In this study, participants (N = 25) were interviewed using both open- and closed-ended questions, and results were analyzed using a constant comparative method. The most common method of teaching documentation skills was some variation of the demonstration–return–demonstration method. Faculty members were concerned about the amount of time it took to hone documentation skills in the actual clinical area, indicating that a median of 2 hours of an 8-hour clinical day were consumed by this task, and shared that there was seemingly little documentation taught in the classroom or laboratory. Faculty relied heavily on experts in the clinical setting and used their documentation as models for students to emulate. In the case of the EHR documentation, on-site nursing experts proficient in the use of the system were especially useful as role models. However, faculty remained concerned that using the electronic system and the endless drop-down menus might actually interfere with the development of nursing expertise and critical thinking.

One crucial issue that was shared by faculty regarding electronic documentation was that the clinical facility provided the instructor with only one access code so that all the students in the clinical group used the same code to document and there was limited access to computers on the clinical

unit. The faculty was very concerned about the legal and ethical issues for appropriate documentation and the provision of care, such as on-time medication administration in a group of 8 to 10 students with one access code.

The authors suggested the need to integrate information competencies throughout the curricula and provide opportunities for faculty development in informatics. They suggested that "faculty competencies in the area of informatics must be identified and standardized" and faculty must learn to "model self-efficacy: the patience, support and persistence that characterize individual development within a professional discipline" (p. 620).

The full article appears in: Mahon, P. Y., Nickitas, D. M., & Nokes, K. M. (2010). Faculty perceptions of student documentation skills during the transition from paper-based to electronic health records systems. *Journal of Nursing Education*, *49*(11), 615–621. https://doi.org/10.3928/01484834-20100524-06.

A qualitative research study by Kennedy et al. (2009) described the experiences and development of nursing process skills in nursing students (N = 5) using the Simulated E-hEalth Delivery System (SEEDS) learning innovation. In the SEEDS learning innovation, students were given written case studies and asked to enter the patient data in a simulated EHR and generate a care plan for the patient and family. The authors concluded that "[t]he technology provided an interactive venue for developing nursing process skills by linking assessment data from case studies with foundational concepts in nursing. . . . The exercise was authentic, dynamic, and learner centered" (p. 99). As a result of the themes discovered in this qualitative study, the authors proposed two hypotheses for future research to explore learning outcomes resulting from the use of a simulated e-health system:

> *Interaction is greater among technologically competent students who use electronic documentation for patient data during clinical conferences. These students interact more freely with other students and their faculty members and experience enhanced learner satisfaction. These students also demonstrate superior nursing process skills compared to students using traditional post clinical group discussion about patient care*.

Technologically competent students also have higher test scores on specific topics compared to students who use paper-and-pencil means to organize the assessment data and develop care plans.

The full article appears in: Kennedy, D., Pallikkathayil, L., & Warren, J. J. (2009). Using a modified electronic health record to develop nursing process skills. *Journal of Nursing Education*, *48*(2), 96–100. https://doi.org/10.3928/01484834-20090201-07.

Debriefing a simulation scenario is enhanced when a fully functional EHR is included. The EHR is linked to the simulation scenario and contains all the pertinent patient information for learners to access before or during the simulation scenario. It is imperative that the system incorporate the ability for learners to document just as they would in an actual clinical setting, with the capability of submitting the documentation to the instructor for evaluation and feedback. Being able to do this helps students feel practice ready. A major strength of this type of system is that it is a prepackaged, web-based solution that does not need to be created from scratch. Vanderbilt University Medical Center went with Epic. According to Raths (2020), "A decade ago, many academic medical centers built homegrown EHRs based on the innovative work of their own informaticians. Now, by and large, those same health centers use commercial EHRs from Epic or Cerner" (para. 1). Vanderbilt wants to guarantee that students, faculty, and clinicians can access data, investigate and test innovations, and assess the results.

In addition, many learning systems designed for simulation contain all the necessary tools for the instructor or simulation center staff to build the simulation scenario, including but not limited to programming guides, staging and scripting information for the scenario, and debriefing guides. Two potential disadvantages with any commercially available solution, however, are the cost to purchase it, which varies depending on the product and vendor, and the ability for or cost associated with customization.

Although the main disadvantages of a live system were discussed at the beginning of this section, the use of a real EHR system clearly provides learners with a truly authentic experience. One innovative solution to bridge this gap was developed out of an academic–business partnership between the Cerner Corporation and the University of Kansas School of Nursing. The SEEDS incorporated the use of Cerner Corporation's clinical information system and PowerChart application (Connors et al., 2002). This system was specifically adapted for educational purposes to address the learner's informatics needs. Similar to the WMC system, discussed previously, instructors developed the patient data stored within the Cerner

Corporation's clinical information system database to create virtual patients within the system. Students could navigate through the system to view pertinent patient data and then document assessment information and create a plan of care within the PowerChart application. In addition, the instructor could access student documentation for evaluation and feedback. The SEEDS marked the first time a clinical information system was used in a simulated way for teaching curriculum content to health professional students (Kennedy et al., 2009). Refer to Research Brief 1 for a discussion of a study on the use of the SEEDS approach.

Challenges and Opportunities

The adoption and use of simulation technologies present unique advantages and disadvantages. Using simulated medical records, either as a stand-alone learning tool or in conjunction with a complete simulation scenario, provides the learner with an opportunity for a realistic, hands-on learning experience. Major considerations when looking to adopt a simulated EHR include (1) cost, (2) ease of use for the instructor and learner, (3) technical support from the vendor, (4) time to build or develop the patient database, (5) additional simulation materials included with the package, (6) flexibility of the system to be customized and used as a stand-alone tool or in the setting of a full-scale simulation scenario, and (7) overall **fidelity** (i.e., realism).

In 2006, a coalition consisting of experts from the fields of health care, informatics, business and industry, and nursing proposed the Technology Informatics Guiding Education Reform (TIGER) initiative (Healthcare Information and Management Systems Society [HIMSS], n.d.). The aim of this group is to advance the integration of informatics core competencies into nursing education to provide better and safer care to patients. Of particular interest is the call to take an active role in the design and integration of informatics tools that are intuitive, affordable, usable, responsive, and evidence based (HIMSS, n.d.). This approach promotes truly new and innovative strategies for informatics education and creates significant opportunities for collaboration among industry, academia, and clinical practice.

The Future of Simulation in Nursing Informatics Education

Simulation will clearly play an important role in the development of informatics competencies for student nurses and practitioners. One theme of simulation-based learning is practicing just as a nurse would in the actual clinical setting. Regarding facilitating the growth of informatics competencies, it is no different. If there are expectations regarding the use of clinical information systems and EHRs in the clinical setting, then the opportunity also exists for the incorporation of such tools into the classroom and simulated clinical setting.

Aside from using the simulated EHR in the setting of a clinical simulation scenario, opportunities also exist to incorporate the simulated EHR into the classroom in new and innovative ways. As mentioned at the beginning of the chapter in the second simulation example, the EHR can be used as an active learning tool within the classroom. Rather than requiring students to absorb information from a book, the EHR can become a powerful way for learners to make important connections about caring for patients with a specific disease process or to learn concepts of pathophysiology or pharmacology.

Game Mechanics and Virtual World Simulation for Nursing Education

Setting the Stage

The use of game mechanics in educational, or serious, games and virtual world simulation continues to grow, with a great deal of research effort and funds directed toward the discoveries of their best uses. Educational games and virtual world simulations share some characteristics, and it is difficult to find a pure experience in any of the genres. Simulations may have gamelike qualities, and virtual worlds may be used to present a simulation.

Case Scenario

Joe sits down at the computer and logs in to StratWorld, a virtual world that enables users to create their own team and then compete against other teams created by other StratWorld players. The developers of StratWorld created interesting challenges, part intellectual and part brute force, which teams strive to solve before competing teams solve them first.

After Joe logs on, he is presented with a **three-dimensional (3D)** view of a forest. Directly in front of him is a 3D figure that looks very much like Joe, except for having broader shoulders, a more rugged face, and better skin complexion. This is Joe's **avatar**, his representation of himself in StratWorld. Joe can change his avatar's appearance as he wishes, but he likes to stick to something close to what he actually looks like. All the members of one of his opposing teams in StratWorld prefer to appear as masses of glowing tubes, but Joe thinks they are strange.

Today, he is recruiting for his virtual team, so he ducks into his inventory (i.e., a place to store items his avatar can wear and use) and dons his manager's jacket. "Joe's Team" is proudly displayed on

the back. Joe is proud of the jacket; he created the lettering himself in a graphics program, uploaded it to StratWorld, and then added it to a plain jacket and gave a copy to all new members of his team. As in many virtual worlds, clothes do make the man, woman, or thing.

Using the arrow keys and the mouse to manipulate his avatar, Joe begins to make his avatar walk down the forest trail. He is looking to recruit an ogre for his team to beef up its physical offensive capabilities and replace the recent loss of Charlie the unicorn. Ogres are big and strong, perfect for the task. Joe is a little nervous because he has never been to this part of StratWorld before and explorations in new areas can be fraught with peril. After a brief sojourn, Joe comes upon an ogre sitting in a daisy-strewn clearing, picking its teeth with a small sapling ripped from the ground. "Ogre!" Joe shouts. "I need someone to smash through things for my team. Interested?"

"What's in it for me?" the ogre asks, thumping its chest with the remains of the sorry sapling and splintering it into oblivion. "Darn! That was a good toothpick!" The chirping of birds and the droning of insects in the foliage, all part of the normal background noise here, suddenly stop. Joe picks up on this environmental clue and, just as in the real world when this happens, knows he is in danger.

Joe ponders the question. He knows he is talking to a **nonplayer character (NPC)**, one that seems to have a brain behind the 3D facade but that in reality has very clever programming attached to it so that it can seem to carry on an intelligent conversation. Some companies call this artificial intelligence, but both the creators of these environments and the scholars who study them hotly debate the proper use of that term. Joe also knows that the world is constructed so that he has to balance his profits from game wins with overhead costs, such as players' salaries and equipment maintenance. He needs to make an offer to the ogre. An offer of too little would insult the ogre, and a fight between it and Joe would be the probable result. Joe's avatar could die, an inconvenience that would cost him time and loss of reputation with other StratWorlders. A generous offer would probably be accepted but might bankrupt

Joe over time. Joe needs to balance his needs and costs and think outside the box. It is a complex problem-solving situation!

"Okay, Ogre, here's the deal. Pay is $900 a month, and . . ." Joe attempts to continue, but the ogre quickly rises in an aggressive manner. "Wait! Let me continue! I know that's a little less than normal, but I'll throw in a nice, new sapling each week for tooth maintenance! How about it?"

The ogre sits back down and eyes Joe warily. "Just need to pick tooths, not maintain ants. Contract for . . ." (the ogre pauses to quickly count its fingers) "10 months?"

"Sure, sure, but if you are injured, you go to half pay until you can play again," Joe answers.

"I still get toothpick each week, even if hurt?"

"Absolutely. I mean, yes."

The ogre leans forward on its haunches. "Sound good! You go. I follow."

"One more thing, Ogre. What do I call you?" Joe asks.

"Daisy! You managers sure are stupid!"

Joe takes Daisy back to his office by teleporting there, which is a way to move from one place to another with a simple click of a button. Joe pulls up a map of StratWorld, locates the land he owns, and clicks on it for instantaneous transport. Joe sends Daisy the ogre to practice smashing down walls in his training field and then pauses for a moment to admire his recreation of his grandfather's old rolltop desk. He recreated it from an old photograph just for his office in StratWorld. Looking out the window, he sees Daisy running out on the training field. He sits down at his desk to go over his team's statistics. With the addition of Daisy to the team, Joe needs to recalculate all his strategies. He must determine how he can acquire a sapling each week for Daisy. Where will he get one, and how much will it cost? Then he needs to send out an acceptance to a recent invitation from the game developers to participate in next week's challenge. A win would be sweet, but it will be a busy week of preparation!

Before Joe hunkers down to work, he sends an instant message to Kathy, an admirable opponent in StratWorld against whom he has

competed several times. Typing furiously and with a certain glee, he writes, “Hi, Kathy, guess what? I’m gonna DUST your team in the next challenge!” Kathy’s reply is swift: “Bring it on, Joe, bring it on!”

Case Scenario Discussion

This is a brief description of what occurs in many online virtual environments today. People create a presence in the environment and then manipulate events for a desired outcome. They explore, build things, interact with others, and try to achieve goals. The story is fictional; there is no StratWorld, but games do exist for which people build teams and compete against one another. So is StratWorld a simulation, a virtual world, or a game? What do you think? Think about simulations you have experienced or heard of, games you have played, and anything you have read about virtual worlds. Try looking up some definitions online. Write down your thoughts, and come up with some justifications that back your decision.

Note that avatar realism continues to improve; some are so humanlike that they are referred to as virtual humans (Stuart, 2018).

Game Mechanics and Educational, or Serious, Games

Game mechanics are, simply put, the rules and limitations in which a game takes place. It is imperative that the rules be clearly stated in the instructions so that the players know what is expected of them and what the rules are that the game itself must follow. The mechanics determine how the players interact with the rules and the game responds to the players' moves or behaviors within the game, thus connecting the players' actions to the purpose of the game. People voluntarily play games because they are fun and embody many motivational aspects (Mastrian et al., 2011). Great games provide an optimally challenging state between boredom and frustration (Csikszentmihalyi, 1990). Games exist within a set of rules (Kelley, 1988; Salen & Zimmerman, 2003), and players receive feedback from their interactions in the game and rule space. According to Chen (2012), the rule space model facilitates the cognitive assessment and breakdown of a learner's skill and provides an understanding of the learning topics or concepts that are weaknesses or strengths for each learner.

Educational, or Serious, Games

Educational games are created intentionally for learning and fun, or edutainment; these games are referred to as **serious games**. They are a melding of educational content, learning principles, and computer games (Prensky, 2001) that should emphasize the value of the experience (Nemerow, 1996). Mungai et al. (2002) stated that the flow of an educational game may be under the designer's control more than that in a noneducational game and that feedback should be used to stress competency, not just achievement. The trick in designing an educational game is to maintain the same fun state found in noneducational games (Koster, 2004). "Contemporary

teachers wishing to incorporate game-based learning whether doing so within a virtual environment, through video games, or by leveraging mobile apps and other technologies are at the forefront of a paradigm shift" (Bauman, 2016, p. 110).

Many types of games exist, and each type has a different potential for educational use (Mastrian et al., 2011). To learn to respond quickly and hone reflexes, action games may be used. Adventure games may be used to discover the unknown, such as diagnosing a patient's illness. Construction and building games could be used for building complex mental constructs that can be understood only through knowledge of their constituent parts and the ways in which they interrelate. Strategy games are great for nursing education teaching moments where careful, up-front planning is critical and on-the-fly adjustments to one's plan may be needed to ensure its success.

In role-playing games, the player takes on the role of one or more characters and improves the character while progressing through a storyline. Today, **massive multiplayer online role-playing games** are very popular; they use the internet to provide a shared, simultaneous experience for dozens or even hundreds of players. Role-playing games are an excellent way for nurse educators to guide students through any situation where a sequenced step-by-step introduction to the parts of the job or skill is required.

Casual games, also known as mini-games, are fairly new. These games are designed to be played in a short time span or for a few minutes a day over several days, weeks, or even months. Many online, browser-based games fit this category. Casual games may be useful for continuous reinforcement of basic concepts, emulating a slowly changing environment, and modifying the players' attitudes on a given topic over a period of time. To date, these games remain largely untapped as educational tools.

There are also gaming simulations. A simulation game uses game mechanics to imitate real-life activities in the form of a game. Refer to Research Brief 2 for a mixed-methods, quantitative and qualitative, study on the health and safety of home healthcare professionals, including nurses.

RESEARCH BRIEF 2

Darragh et al. (2016) stated that the rapid increase in home healthcare services is driving a need for additional trained home healthcare professionals. The training must be effective for managing personal health and safety hazards encountered when providing healthcare services in the home environment. The process of developing and evaluating an interactive virtual simulation training system to educate home healthcare professionals, including nurses, was described.

Sixty-eight home healthcare professionals participated in the study, with the majority being white (71%) and female (95%), with an average age of 49 years (with a standard deviation of 11.8 years). Sixty-seven percent worked in Ohio and Kentucky. The participants represented registered nurses, aides, homemakers, administrators, educators, occupational therapists, and physical therapists.

A mixed-methods design, qualitative and quantitative, using an interdisciplinary, participatory design methodology was used to develop a virtual simulation system to train home healthcare professionals to identify and manage health and safety hazards in the home using a gaming simulation learning approach. The participants identified the layout and features of a typical client's home to the interdisciplinary research team. Once the working version of the virtual simulation training system was created, assessment of its usefulness, usability, and desirability was ongoing to continually develop and modify the system.

Quantitatively, the researchers used the Modified Home Healthcare Worker Questionnaire (MHHWQ) and the usefulness, usability, and desirability (UUD) survey. Qualitative data collection consisted of structured focus groups and individual interviews. The participants described 353 hazard management dilemmas and explained multiple types of "making do" solutions for the hazards, most of which were classified as "less-than-optimal."

The simulation game facilitated active learning and critical thinking processes crucial for these professionals because they are typically highly autonomous professionals who work independently in unpredictable environments where they must problem solve to create solutions to unforeseen or complex events that affect their health and safety as well as the health and safety of their clients.

To prepare professionals using health and safety trainings, the training must focus on realistic scenarios, flexible solutions, and independent problem-solving activities. The virtual simulation training system includes immersion and engagement through a process of identification, response, problem-solving, and feedback. The professionals had to assess the environment for

hazards in several rooms. Then they received feedback about correct identification and right and wrong answers, problem-solving about potential strategies, and assessment of progress in both a training and an evaluation environment; the feedback facilitated deliberate practice, which is a powerful component of skill acquisition.

The researchers concluded that participatory methods are a useful and effective way to design a virtual simulation training system that is interactive, engaging, and informative. Since this project is ongoing, their long-term goal is to improve the health and safety of home healthcare professionals who work in clients' homes.

The full article appears in: Darragh, A., Lavender, S., Polivka, B., Sommerich, C., Wills, C., Hittle, B., Chen, R., & Stredney, D. (2016). Gaming simulation as health and safety training for home health care workers. *Clinical Simulation in Nursing*, *12*(8), 328–335. https://doi.org/10.1016/j.ecns.2016.03.006

Virtual Worlds in Education

A 3D virtual world often mimics a real-world environment, although it may also include supernatural abilities, such as flying unaided (Mastrian et al., 2011). Users of virtual worlds are often quick to stress that these creations are not games, although this confusion is easy to understand because virtual worlds share many of the same interface characteristics as 3D action and role-playing games.

The best use of virtual worlds for educational purposes may occur when there is a need for an **immersive experience** coupled with a need for social interaction. For example, in the virtual world of **Second Life**, one university has developed a virtual hacienda for students learning Spanish (Clark, 2009). Students interact with the environment and the objects in the hacienda while speaking to one another in Spanish, thereby participating in authentic learning activities. Some of the Second Life scenarios used by a college of nursing include a real human resources representative whom the student must call; the pair must discuss the situation, and the student then determines a solution based on the representative's input. This activity immerses the students in their role and fully engages them in the learning episode. Cohen et al. (2012) tested the use of a virtual world as a training site for emergency preparedness and coordination for first responders in major incidents (e.g., a terrorist attack) and concluded that

> *[m]ajor incident exercises are complex in nature and expensive and they thereby require novel methodologies to aid training and preparation. This study has established the feasibility of developing low-cost, immersive, accessible virtual environments for major incident preparation using a systematic approach. Both the environment and scenarios were deemed realistic and acceptable for training and testing of existing plans by clinicians.* (pp. 83–84)

Virtual worlds need not be 3D. Predecessors to the 3D environment include the **multiuser dungeon**, **object-oriented multiuser dungeon**, and multiuser shared hallucination. All of

these environments are text based, so the user receives environmental information as passages of text, manipulates objects, and talks to others by typing text commands. Multiuser dungeons, object-oriented multiuser dungeons, and multiuser shared hallucinations are still in use today.

Choosing Among Simulations, Serious Games, and Virtual Worlds

Simulations; educational, or serious, games; and virtual worlds overlap a great deal. Games may be placed in virtual worlds, and simulations may have gamelike elements. Yet these three tools also have distinctive characteristics. By examining several of these key characteristics (i.e., goal orientation, competition, fun factor, exploratory learning, and social interaction), choosing the correct tool for teaching purposes becomes easier.

Games are goal oriented and may be competitive in nature. They should be fun and perhaps a bit fantastical and lighthearted. A particular game may or may not include exploratory learning and social interaction. Although simulations are also goal oriented, the competition is generally subdued. Simulations are typically more realistic and not necessarily fun to use. A particular simulation may or may not include exploratory learning and social interaction. Virtual worlds do not intrinsically have goals or competition; it is up to the player to construct them and add them to the world. Virtual worlds may include fantastical elements. Virtual worlds generally lend themselves to exploratory learning and social interaction. When educators develop virtual worlds for education, they can control the scenarios or activities that the learners experience. Virtual worlds used for simulation also include a debriefing process for their learners, which solidifies the learning.

Realities

The realities have been described as disruptive innovations (see the Disruptive Innovations box). Using virtual realities in education requires immersion. The expectation of immersive learning is that learners will become absorbed, engrossed, and engaged in the learning activity to the point that they suspend their own reality and

truly experience the virtual scenarios and simulations as if they were real; they feel that they are actually participating in a physical setting instead of the virtual, synthetic, artificially generated environment. Augmented reality (AR) and virtual reality (VR) are technological examples of immersive environments used in learning episodes to enhance the learning experience in a safe setting.

Augmented Reality

Augmented reality (AR) is an interactive experience within a real-world environment that enhances real-world objects using virtually simulated, or computer-generated, perceptual information. Integrating AR into educational venues provides stimulation, or input, for multiple senses, including olfactory, visual, auditory, haptic, and somatosensory (e.g., pressure, pain, or warmth). It comprises apps; wearable technologies, such as glasses; and software that not only interacts with users but also enhances their senses with data, information, audio, and images.

DISRUPTIVE INNOVATIONS

Disruptive innovations are new developments that radically change, or disrupt, the way structures or industries function. They are the introductions of products or services into well-known or established industries that outperform all other products or services (i.e., are more efficient and lower priced), thereby obtaining competitive advantages, which capture the market share and alter and transform those industries.

Thinking about the internet, how did it disrupt education? Examples of disruptive innovations that are game changers follow. Reflect on each of them, the disruption they have caused as they evolved and how their disruption affects nursing education.

- Surgeon using VR to practice a surgery using the patient's own anatomy so that in the actual surgery, the risk of the surgeon being met with an unanticipated event is minimized. Will this preparation be the norm for all surgeries going forward? If so, how do we educate current practitioners and students who will be the future healthcare professionals in the workforce?

- Artificial intelligence (AI)
- Internet of Things (IoT) and Artificial Intelligence of Things (AIoT)
- Blockchain technology
- Robotics

What other disruptive innovations can you think of, and why were or are they disruptive, or game changers?

AR does not require specialized equipment; the digital information is overlaid on an image of something being viewed through a smart device's camera. AR has been integrated into nursing curriculums to help nursing students achieve and improve clinical skill proficiency. AR improves the abstract, or conceptual, comprehension of phenomena. Faculty members can bring abstract concepts to life with AR expeditions in which they and the students actively explore. Learners can view and manipulate digital animations, such as a beating heart or human brain, by bringing them into their real background. This helps nursing students understand the relationships of diseases and normal pathophysiology. Nursing students can also better understand the effect of procedures in relation to the anatomy and physiology of their patients. AR is a learning experience that enhances critical thinking skills and clinical judgment.

Virtual Reality

Virtual reality (VR) is infiltrating health care to improve plans of care and patients' outcomes. Heady (2019) described the use of VR at the University of California at Los Angeles to explore the patient's own anatomy prior to surgery. VR "models to prepare for kidney tumor surgeries resulted in substantial improvements, including shorter operating times, less blood loss during surgery and a shorter stay in the hospital afterward" (para. 1). VR is also being used to distract patients during painful and/or lengthy procedures, such as helping patients stay relaxed and comfortable while receiving chemotherapy (Pratt, 2017), and for pain management. Brody (2019) said that for pain management, it is more than a distraction:

"It's more like a brain hack that occupies the brain so fully that it has no room to process pain sensations at the same time" (para. 1). "Through the hospital's [Stanford Medicine Children's Health] CHARIOT program [www.stanfordchildrens.org/en/innovation/chariot], Packard Children's is one of the only hospitals in the world to have VR available on every unit to help engage and distract patients undergoing a range of hospital procedures" (Stanford Medicine Children's Health, n.d., para. 2). VR integrations such as these demand that nurse educators prepare nurses to function in environments that expand into VR so that they can actively participate in the evolution of the technologies being used to enhance patient care.

See Research Brief 3, which discusses VR airway research. Dr. McGonigle worked with the students and faculty as they experienced the VR airway lab during this research project; she felt their excitement and how they reacted to the immersive VR environment. Based on this type of research, innovative nurse educators and experts in nursing education and informatics are designing VR scenarios and simulations for nursing students. The VR learning episodes exist in a controlled virtual environment that immerses nursing students in the educational experience. They are able to practice and learn by doing in VR and are being familiarized to this technology.

TOWARD A VIRTUAL FUTURE OF MEDICAL SIMULATION

Medical simulation is a vitally important learning modality and has been proven to reduce errors, improve patient outcomes, and save lives. However, access remains relatively expensive and dependent on the physical hardware space of simulation centers and high-fidelity mannequins. Virtual technologies offer the opportunity to massively expand access to medical simulation to anyone, anywhere, anytime.

Following the trend of so many industries touched by virtualization, medical simulation is beginning to realize a similar trajectory. The physical

infrastructure required to support industries such as film, newspapers, music, and magazines is an example of this transcendence into digital counterparts. In each case, this transition substantially lowered costs and increased access while introducing explosive new growth opportunities that were never before possible. The same will be true of medical simulation.

Virtual counterparts to the physical "stuff" of simulation are already growing rapidly as numerous studies validate their efficacy. Perhaps most importantly, those who never before had access will soon enjoy expansive libraries of digital environments, equipment, patients, and scenarios to advance their hands-on and critical thinking skills.

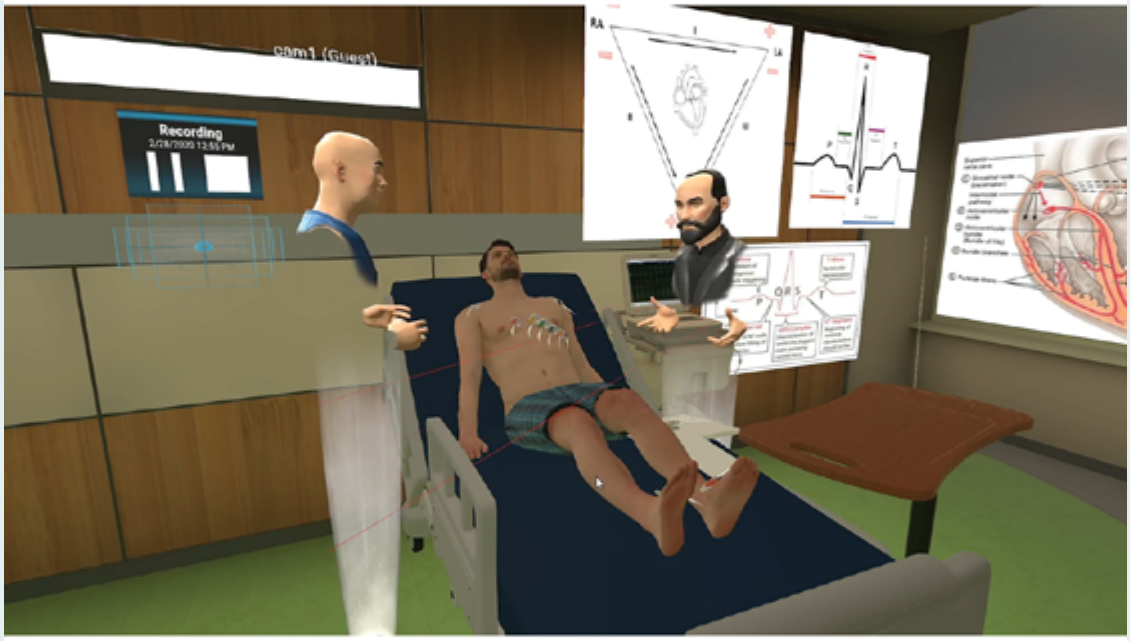
Virtual simulation also introduces powerful network effects by building bridges between experts and participants joining from rural or remote locations. The simulation center of the future is no longer an isolated physical location but rather an interconnected node with real-time access to a perpetually evolving library of expertise and validated best practices.

Virtualization also enables simulation to take lateral steps and expand beyond an isolated scenario narrative into a broader chronology of events that are more akin to the realities of clinical experience. It can more easily bridge between professions, thus enabling cross-disciplinary training on a level that has never before been possible.

Looking ahead to the future of virtual simulation, we may begin to completely rethink and expand its role far beyond what is familiar today. Moving beyond the mere simulation, we might envision fictitious patients and scenarios transitioning into a mirror world of real-time patient interactions that span the entire spectrum of health care.

Patients in the future might opt in to maintain a real-time, digital counterpart of themselves and thus enable procedures to be rehearsed virtually. Imagine an emergency room team rehearsing lifesaving procedures on a patient's virtual replica, trying different approaches and realizing potential complications long before the ambulance arrives.


Anita (a recording)


Recording







Actual image from Acadicus. Inclusion in this text was permitted by Jon Brouchoud, CEO, Arch Virtual, Developers of Acadicus

RESEARCH BRIEF 3 TEACHING AIRWAY INSERTION SKILLS TO NURSING FACULTY

AND STUDENTS USING VR: A PILOT STUDY

PURPOSE OF INVESTIGATION

To examine whether an educational intervention with a pilot contemporary immersive virtual reality simulation (CIVRS) builds knowledge and is feasible to implement among nursing students and faculty.

INTERVENTION

VR airway lab intervention with six adjunct narrated lessons:

1. Bag valve mask
2. Oropharyngeal airway
3. Nasopharyngeal airway
4. King laryngeal airway tube
5. Laryngeal mask airway
6. Endotracheal tube

SURVEY SAMPLING

N = 31 (10 faculty members and 21 students)

THEORETICAL FRAMEWORK

- Bauman's Layered-Learning model
- Situated and multimodal approach
- Knowledge building occurs by leveraging contemporary educational technologies
- Scaffolding knowledge transfer for learners
- Faculty roles shift to facilitate users' discovery of knowledge
- Technology enhances opportunities for mastery learning, moving learners from didactic preparation to and through the simulation to the practice pathway

METHODOLOGY

- Survey sampling
- Quasi-experimental
- One-group pre- and posttest design

APPROACH

- Enact the VR intervention
- Virtual Presence Questionnaire
- Virtual Reality Sickness Questionnaire
- Knowledge test

RESULTS

Faculty and students rated the VR airway lab as having a high level of virtual presence and reported no cybersickness and significant improvement of knowledge of airway management ($p < 0.0001$).

CONCLUSIONS

- The VR airway lab was an efficacious means of teaching difficult airway management skills to nursing students.
- A VR airway intervention was presented to teach difficult airway management using six different airway adjuncts.
- Students and faculty widely accepted the intervention.
- The researchers recommended that further research be conducted to evaluate this immersive, educational delivery medium.

The Future of Simulations, Serious Games, Virtual Worlds, and the Realities in Nursing Education

The use of simulations, games, and virtual worlds in Western society continues to increase. The combination of best practices supported by sound research, the ever-growing power of technology, and learners who grew up using these environments will lead to greater use of these tools for learning (New Media Consortium, 2007).

In addition, games are becoming less expensive to produce and consume. Game development engines, which were long the exclusive domain of major game development companies, are now available at a cost that many users and organizations can afford. Some games come with built-in development tools, which are the game producers' attempt to use free labor to extend their products (Dyer-Witheford & de Peuter, 2009). The growth of indie (i.e., independent) game companies is leading to a plethora of cheap yet high-quality games. The same holds true for virtual worlds. New virtual worlds spring up all the time. Many offer free (sometimes with limited functionality) accounts, and educators are exploring these spaces with increasing regularity for building fantastic learning environments.

Companies are tapping mobile devices as another avenue to push out their games. These devices are already used for a variety of communication and social functions, so why not expand that platform with casual games that rely on social interactions? Expect to see much more happening in this space in the near future.

Another related area of growth is in **augmented-reality games (ARGs)**. Augmented reality occurs when one uses a device, such as a smartphone, to overlay additional information on the real world (Klopfer & Squire, 2008). For example, one might use the camera in the phone to view the stars at night and see on the phone's screen both the stars and the constellation labels and linking lines between

the stars in a constellation. ARGs exploit this concept in gamelike ways, bringing people together physically and virtually to solve a series of challenges. In education, ARGs may be used to provide a fun way to collect and analyze data, collaborate with other students, and access information resources and a new way to look at the world.

Serious games may also have a place in helping practicing nurses maintain or hone skills. Baker (2009) suggested that gaming has a place in continuing education. The science of nursing practice encourages nurses to ask questions, promote dialogue, share lessons learned willingly and openly, and make the outcomes of their patients constructive and positive. Rigorous, high-quality evaluation and research into the teaching and learning techniques offered by serious games can offer insight into future changes not currently conceived of. For example, if a serious game could effectively assist nurses in maintaining the skill set required to care for a patient who is experiencing hypothermia, would that be worth the investment? If a serious game could reduce medication errors in the operating room by 50% to 75% compared to what has been demonstrated in the past, would that have value? If it were found that after implementation of a serious game, a facility experienced zero errors in right-site, right-procedure, and right-patient events during a 10-year period, would this be of value (Baker, 2009, p. 173)?

Serious games can be used to educate health professionals or use their collective knowledge. Foldit (2018) was designed to solve puzzles for science. Foldit had a crowdsourcing computer game that challenged its players to create a protein that could be used as a vaccine for malaria.

The best uses of all these technologies and approaches related to nursing education remain a bit murky (Bauman, 2016, p. 110). Fortunately, the findings of a great deal of research that is currently underway will guide future educators toward the most effective uses of educational games, simulations, and virtual worlds. In an ideal world, educators would have a plethora of available, well-designed, and educator-certified games from which to choose that mesh with the educational objectives of their classes, courses, and curricula.

The two realities of AR and VR are revamping nursing education. They can enhance critical thinking, clinical judgment, and competency and skill attainment. These realities are typically available to the student 24/7 for exploration and practice. As disruptive innovations, they are transforming our educational paradigms and providing interactive, experiential learning. In the future, what is now innovative will be mainstream. Please refer to Chapter 25, *Our Expanding Realities and the Metaverse,* for more about reality and the realities.

A STUDENT IN THE NOT TOO DISTANT FUTURE

Dee McGonigle

Nell walks up the steps of the Diamond building on Treemaunt campus. It's a nice day, and she quickly uses her cybervision contacts, or "Cyves," to check the weather. Appearing before her in midair is a map of the local area, with weather data on her visual periphery. Even though all of the map looks clear, she flicks her eyes toward the data, causing them to move toward her center of vision. Sure enough, there is a 20% chance of rain by 4:00 p.m. Bummer. Nell dismisses her private heads-up display with another flick of her eyes and proceeds into the building. "Oh well," she muses, "at least I'll be home well before then."

Nell steps into the classroom for the first time. She's early; only a few other students have preceded her. Sitting down, she again calls up her Cyves and checks her social networks. One friend is at the beach and live broadcasting a view of the tide coming in. Another is at work, lamenting the slow, archaic T9 connection he has to the internet.

More students file in. Nell fires a quick note to her working friend. "Archaic! You should see this classroom! Probably the same chairs my grandmother sat in!"

"Hey!" her friend replies. "I read all about the Diamond building. It may look old, but it's outfitted with the latest stuff. Wait till you get one class in—you'll see!"

Nell takes a moment to review the results of a smart scan she started last night on the upcoming gardening season; correlated for her are a set of recommendations for her gardening efforts this year. It looks like it will be a dry season, so the tomato variety she grew 4 years ago will probably do well,

although the report notes that she rated them only a 3 out of 5 on her personal taste scale. The smart scan also lists a number of new tomato varieties she might want to use, inferred from her personal taste scale, which she's added to over the years.

Just then, an older woman enters the room. She is dressed casually but has an air of authority about her. *Must be the prof*, thinks Nell. A quick scan with her Cyves confirms it. Around the woman springs virtual data, visible only to Nell:

- *Name:* Dr. Janice Stephenson
- *Occupation:* Professor of Sociology, Treemaunt University
- *Hobbies:* Golfing and reading

The rest of the data are scrambled. Only people whom Dr. Stephenson has given rights to can view them. "Probably pictures of her cats," Nell quietly snorts.

While Nell is sizing up her professor, the professor is doing the same with the entire class. The professor gives Nell a quick look and a brief smile, leaving Nell a bit disconcerted. *What did she read? What DIDN'T she read when she scanned me? Oh boy*.

"Welcome, class!" begins Dr. Stephenson. As she speaks, a large video screen behind her springs to life, and an avatar of her uses sign language to also greet the class. The text of her voice is also visible above the avatar. Nell realizes that everything is being recorded for everyone to view whenever they want. She always prefers the summary personalized to her learning styles that will be available to her.

"This class is an introduction to Treemaunt U and its intelligent enhancements, but it's really more about how to make the most of your experiences here. Many of you probably think this classroom is old fashioned, and until recently, you'd have been correct. But take a closer look. Embedded in each chair is a full connection to the internet. Just push the green button on the side. Go ahead; it's OK," she prompts.

Nell pushes her button and sees her classmates doing the same. Sure enough, a virtual monitor, or air screen, and keyboard appear in the air before her. The chair must have read her public information because it is displaying it just as she views it from her own computer.

"Now," Dr. Stephenson continues, "most of you have Cyves, so you probably don't need this internet access. But it's here for those who do not. You might also notice that the chairs are highly mobile, automatically adjust to your contours, and can be configured in several ways. So breaking up into groups is easy. We can also pull up screens from the floor to partition the room off if need be. Lighting is controllable via several quadrants, making the room very flexible. Imagine what it was like for your parents in college. Can you believe some classrooms had no technology, the chairs were fixed to the floors, and

people were actually uncomfortable as they learned? Amazing! Even the classrooms that had technology were limited. Usually, only the professor had access to the video projectors and the internet. In fact, some professors liked it that way. They actually discouraged students from bringing technology to class. I can't imagine how anyone could really learn without the constant access to information we now have.

"But I digress. Sure, we all know that learning happens many ways. Hopefully, you'll even find me useful as part of your learning experience. You also have access to sources of information that continue to astound me. Most importantly, you have access to each other. Remember that.

"Now, if you look to your right with your Cyves, you will see our virtual eduspace. If you do not have Cyves, use the air screen that popped up when you accessed the internet. The screen will allow you to scan the room like Cyves. You can choose to enter in either two- or three-dimensional mode. Let me know if you cannot see our virtual eduspace.

"Everyone seems good to go. Please enter the virtual eduspace, and find your personalized information packet for review. Your parents probably knew this as virtual reality, but we have gone light-years beyond that. If you have not experienced our virtual settings as of yet, please take some time after class to explore. Remember, you will each have a personal preceptor, an artificially intelligent agent, assigned to you. You will meet your preceptor in our virtual eduspace, which will appear as an intelligent avatar, or intellivar, that you can name and customize. You will also decide which channel it will reside on for you. Your preceptor will be with you throughout the program. It will learn how you learn so that it can help you based on your preferences. There are always hidden gems to uncover and new spaces to discover in the virtual territory for this class."

A man three seats to Nell's right raises his hand. "Yes, uh, Joe?" responds Dr. Stephenson.

"Meaning no disrespect, Professor, but why do we need classrooms at all? We could all just meet virtually, couldn't we?"

"An excellent question, Joe. You're right; we could just meet virtually. We could use Cyves, air screens, or other devices. Yet despite all the wonderful technology we possess, people are still social creatures. We need to be with others, not all the time, but enough so that classrooms are still needed. For this class, we'll meet once a week here. The other two classes will be held in our virtual eduspace. Remember, you can always ask your intellivar to attend a class for you if you are unable to attend.

"Other questions? Ah, I see Mary has posed a question on the back channel for the class. For those of you who are new to all this, we use the technology to create another channel of information, a back channel, as the class proceeds. It's a great way to strike while the fire is hot. Your questions and comments are immediately available and addressed. In this case, our back

channel is simply text on a web page we can easily display. Let's call it up now."

Dr. Stephenson proceeds to display the back channel page on the video screen. It reads as follows:

Mary: I know this is supposed to be an introduction to life as a student, but I'm a transfer student. Do I really need all of this?

Dr. Stephenson smiles. "Thirty years ago, you would have been forced to sit through classes where I, the fount of all knowledge and goodness, would have imparted redundant knowledge into your head. Today, we have ways to avoid that. Remember the battery of tests and quizzes you took as part of your entrance process? They're not just busywork. We've used them to put information about you into our learning management system, Aether. The learning management system will work with your intellivar and prescribe things specifically for you here at Treemaunt U, things you might be interested in and things you definitely need. And for things you already know, you'll be given the chance to opt out of them. You will also receive instruction in the forms you like but not all the time. For example, if you like games and there is a game 'in the open,' meaning it has an Innovative Commons License attached to it so that Treemaunt U can use it legally, and it covers the content you need, guess what? You'll be playing a game! So I believe for you, Mary, there will be some specialized assignments you'll receive—subject to my approval, of course. Maybe I'll even ask you to contribute your information and insights for future classes. Yes, this class and its information are more than just me. They are you. And you, and you, and you. You are all part of the process, so be prepared to be active participants in your learning, not just passive recipients.

"OK, we could probably get through today's class just with me answering your questions, but why don't I go ahead with my outline and whatever I don't cover we can talk about afterward. Oh, and please turn your friend alerts off or on color alert. I know some of you have to take calls and such, but please respect me and your classmates."

The preceding story was a tiny slice of the many possibilities the future holds. It does not begin to touch on the opportunities that nanotechnology, cheap fusion power, or what embedded communication devices might bring to education. Instead, it concentrated on the more tangible possibilities that are logical extensions of what we can do today. The following key elements are alluded to in the story:

- Back channels
- Cyves
- Next-generation morphing classrooms
- Advanced web technologies, social networking, user-created content, and collective intelligence
- Intellivars

- Cloud computing
- Semantic-aware applications
- Smart objects
- Open source technologies
- Learning management systems (LMSs)
- Personal learning environments (PLEs)
- Personalized learning
- Adaptive learning
- Specialized educational modules delivered just in time
- Mobile devices
- Virtual eduspaces; virtual worlds; simulations; and educational, or serious, games

CYVES DEFINITION

Cyves stands for computerized yagi visual earshot sensations. They are computer processors embedded in contact lenses equipped with a visual display as well as auditory channels for communicating. A yagi is a sharply directional antenna.

Summary

Simulated experiences in nursing education contain the PEDA elements, which provide important opportunities for students to hone critical thinking and clinical judgment skills in a safe and supportive environment. Simulation scenarios may also provide a better variety of clinical and practicum experiences than those available in a real setting, and they also provide nursing faculty the opportunity to track student progress and development against specific learning objectives. Nurse educators can share simulation scenarios and experiences and thus contribute to the body of nursing education knowledge to improve education practice. Simulations; games; virtual worlds; and the realities, AR and VR, have a great deal of potential as educational tools for augmenting, supplementing, or even replacing traditional methods of teaching as well as clinical experiences. As educators become more skilled in the use of these tools; designers share their creative works with others; and nurse informaticists lead, collaborate, and support these efforts, we can expect to see these tools blended, honed, integrated, and leveraged more frequently in the coming decade.

THOUGHT-PROVOKING QUESTIONS

1. Consider your experience and learning regarding EHRs. If you were to design a learning program centered on the use of EHRs, what would it look like? Consider this from the viewpoint of an educator, a student, a clinician, and a healthcare administrator.
2. Think about the clinical courses you have taken as a student. Which opportunities and challenges exist regarding the use of an EHR as a major learning tool in conjunction with, or perhaps even replacing, the required textbook?
3. If you were to design a simulation scenario incorporating the use of an EHR, which informatics competencies would you focus on and why?

4. Games are supposed to be fun and voluntary. How can educators force a game on a student and expect it to remain fun and engaging?
5. It can take several hours of gameplay to learn the mechanics of some games and even longer for the more complex games. If subject matter learning can occur only after this initial game mechanics learning occurs, how can educators justify the amount of time a learner must spend within the game just to get to the point where learning begins?
6. If you were choosing between a latex-based and a virtual simulation, what would you list as each of their advantages and disadvantages? Would PEDA elements be present for both?
7. How do educators acquire the training needed not just to get by in these new environments but to flourish, thrive, and mold the environments for their purposes?
8. What realities have you experienced? Describe your experience in detail. If you have not experienced any realities, imagine how AR and VR could affect your education and/or clinical practice setting.

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SECTION VI
Research Applications of Nursing Informatics

Chapter 21 Nursing Research: Data Collection, Processing, and Analysis

Chapter 22 Informatics

Chapter 23 Generating and Translating Evidence for Practice

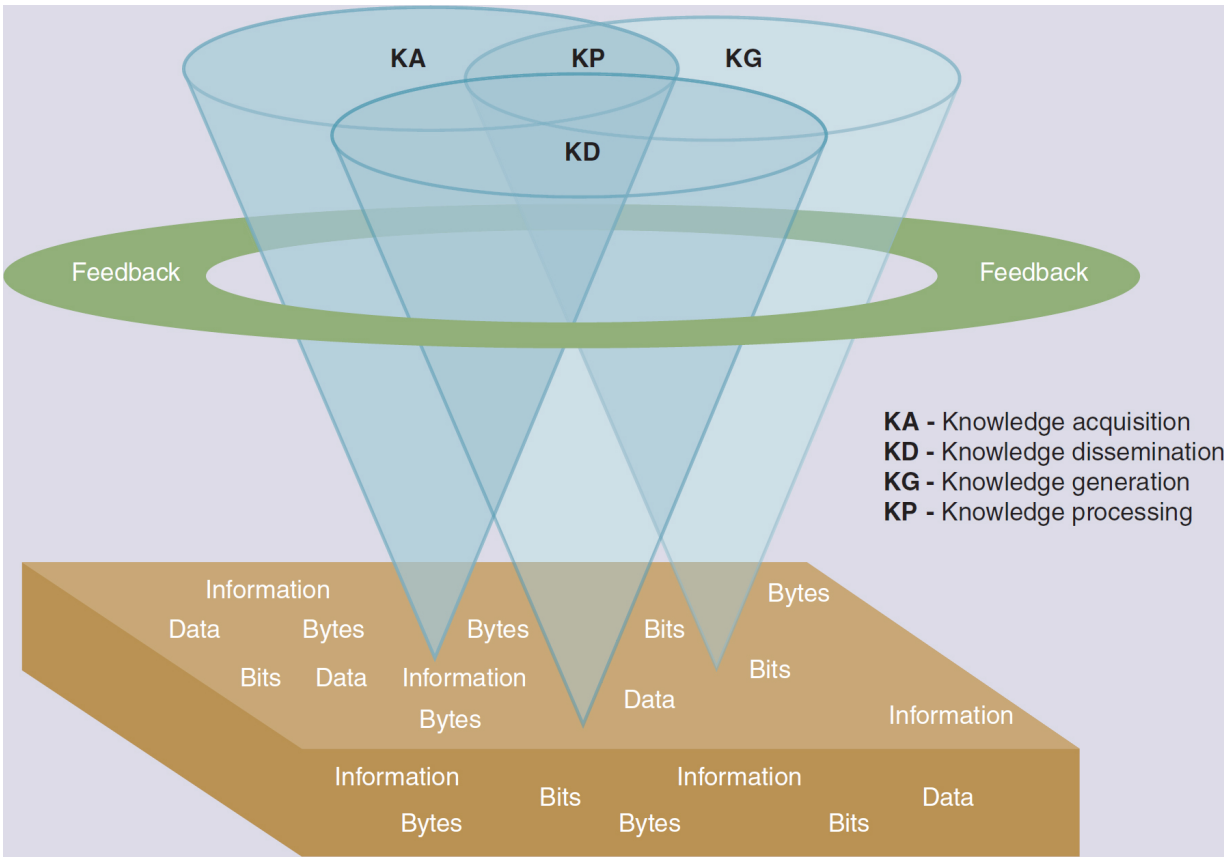
Nursing informatics (NI) provides more tools and capabilities than can at times be imagined. Just as NI has changed the way nursing is administered and practiced, so too has it dramatically altered research practices.

Nursing research has evolved with technology. In the era of evidence-based practice, clinicians must continue to think critically about their actions. What is the science behind interventions? Things must no longer be done a certain way just because they have always been done that way. Instead, one should research the problem, use evidence-based resources, critically select electronic and nonelectronic references, consolidate the research findings and combine and compare the conclusions, present the findings, and propose a solution. The nurse may be the first to ask *why*, thereby becoming a key player in making change happen.

NI enhances and facilitates collaboration; improves access to online libraries; provides research tool transparency for collection, analysis, and dissemination of research knowledge; and facilitates the development of a common data language. It provides organizational and informational support to advance translational research, helping to fill the gap between research findings and practice implementation. Repeat studies are needed to provide meaningful meta-analyses and systematic reviews of evidence to

advance practice. Technology advancement in the area of incorporating evidence into clinical tools must continue. Removing the barriers to knowledge-seeking behavior and providing access to evidential resources promotes knowledge use and, in the end, improves patient outcomes. In addition, NI provides support for powerful research techniques, such as data mining, and research involving biological processes and genomics, which holds the promise of discovering new knowledge to improve clinical practices.

The material in this book is placed within the context of the Foundation of Knowledge model (**Figure VI-1**). Nursing research is conducted to generate knowledge that is used to meet the needs of healthcare delivery systems, organizations, patients, and nurses. In relation to the model, the nurse researcher is involved with every aspect, from acquiring (i.e., collecting) and processing (i.e., analyzing) data and information to generating knowledge and disseminating the results or findings (i.e., knowledge). Through this work, the researcher generates knowledge for the nursing profession, which is extremely important in the advancement of nursing science.



Designed by Alicia Mastrian

Figure VI-1 Foundation of Knowledge Model

Description



CHAPTER 21

Nursing Research: Data Collection, Processing, and Analysis

OBJECTIVES

1. Describe nursing research in relation to the Foundation of Knowledge model.
2. Explore the acquisition of previous knowledge through internet and library holdings.
3. Explore information fair use and copyright restrictions.
4. Assess informatics tools for collecting data and storing information.
5. Compare tools for processing and analyzing quantitative and qualitative data.

KEY TERMS

- American Library Association (ALA)
- American Psychological Association (APA)
- big data
- Cochrane Library
- copyright
- Cumulative Index to Nursing and Allied Health Literature (CINAHL)
- Educational Resources Information Center (ERIC)
- fair use
- Foundation of Knowledge model

- handheld device
- information literacy
- knowledge network
- MEDLINE
- PsycArticles
- PsycInfo
- PubMed

Introduction: Nursing Research and the Foundation of Knowledge Model

The **Foundation of Knowledge model** suggests that the most important aspect of information discovery, retrieval, and delivery is the ability to acquire, process, generate, and disseminate knowledge in ways that help those managing the knowledge reevaluate and rethink the way they understand and use what they know and have learned. These goals closely reflect the Information Literacy Competency Standards for Nursing, published by the **American Library Association (ALA)** in 2013. These standards were derived from the Information Literacy Standards for Higher Education (Association of College and Research Libraries [ACRL], 2000). Specific standards for nursing were developed because nursing excellence depends on the judicious use of the best evidence and is informed by translational research.

According to the ALA (2013), an information-literate nurse is able to do the following:

- Determine the nature and extent of the information needed
- Access the needed information effectively and efficiently
- Critically evaluate information and its sources and determine the need for further information
- Use information effectively to accomplish a specific purpose, either individually or as a group member
- Understand the economic, legal, and social issues surrounding the use of information and access and use information ethically and legally

In addition, new challenges arise for individuals seeking to understand and evaluate information because information is available through multiple forms of media (i.e., graphical, aural, and textual). The sheer quantity of information does not by itself create

a more informed citizenry without complementary abilities to use this information effectively. More significantly, information literacy forms the basis for lifelong learning, a commitment that is required for a professional to maintain competency and navigate ever-changing approaches to care.

CASE STUDY

During rounds, Charles encounters a rare condition he has never personally seen and only vaguely remembers hearing about in nursing school. He takes a few moments to prepare himself by searching the internet for information. That evening, he does even more research so that he can assess and treat the patient safely. He searches clinical databases online and his own school textbooks. Most of the information seems consistent, yet some factors vary. Charles wants to provide the highest quality of patient care and safety. He wonders which resources are the most trusted and which are the most accurate.

Knowledge Generation Through Nursing Research

Information literacy is an intellectual framework for finding, understanding, evaluating, and using information (**Figure 21-1**). These activities are accomplished in part through fluency with information technology and sound investigative methods but, more importantly, through critical reasoning and discernment.



Figure 21-1 Information Literacy

Because nursing informatics (NI) combines all four nursing practice areas (i.e., clinical, research, administration, and education), the ability to recognize the need for a specific kind of information and then locate, evaluate, and effectively use that information is paramount. It is important that nurse educators prepare nursing students for information-literate practice in technology-laden

healthcare environments. Stephens-Lee et al. (2013) stressed that "[n]ursing students require opportunities to help them develop NI skills and abilities to prepare them for contemporary workplaces" (para. 39). Nash (2014) stated that

> *[i]f we desire nurses who practice the art of nursing as well as the science of nursing, we must make it a priority to address the issue of integrating those interpersonal and critical thinking skills we value into an increasingly complex, high-tech, fast-paced healthcare system that often works against us practicing at our very best.* (p. 13)

Nursing students today use technology in their personal lives, and they know that

> *technology allows them to share photos (Flickr), exchange files and images, send videos (YouTube, Snapchat), bookmark (Quorum or Diigo, Pinterest), micro-blogs or short postings (Twitter, Tumblr, MySpace), blog (Blogger), socialize (Facebook, Vimeo, Instagram), search (Google, Google+), and network professionally (Altogether, LinkedIn, Yahoo Groups).* (Merrill, 2015, p. 72)

Nursing faculties must be able to adapt their teaching in this new technology era so that they engage their students and help them assimilate technology as they prepare for their professional nursing roles. Focusing on nurses' providing direct patient care, Piscotty et al. (2015) stated that "finding methods that can help nurses offer safe and effective care using technology is an absolute necessity" (p. 287). As nurses enact their roles as administrators, researchers, educators, and clinical staff members, integrating technology into the current technology-laden information era is paramount.

We must also support the evolution of nursing and assist nurses and nursing students in their quest for knowledge to improve patient care and patient outcomes. They must be encouraged to question how they practice and why they do what they do, recognize the information needs necessary to enact change, and search the literature for evidence. Once they locate appropriate literature, they must be able to judiciously examine and analyze the findings. Following their analysis, they must synthesize, apply, and implement what they have learned from the literature to what they experience

in their practice. If they deem a change in practice is warranted, the change should be instituted and its efficacy evaluated. For this process to work, nurses and nursing students must know how to access the literature, search for appropriate resources, and evaluate specific findings.

Acquiring Previously Gained Knowledge Through Internet and Library Holdings

In an environment characterized by rapid technological change coupled with an overwhelming proliferation of information sources, nurses face an enormous number of options when choosing how and from where to acquire information for their academic studies, clinical situations, and research. Because information is available through so many venues—libraries, special interest organizations, media, community resources, and the internet—in increasingly unfiltered formats, healthcare practitioners must inevitably question the authenticity, validity, and reliability of information (ACRL, 2016).

Often, the retrieval of reliable research and information may seem to be a daunting task in light of the seemingly ubiquitous amount of information found on the web. Focusing on specific information venues not only aids this search but also assists in negotiating the endless maze of resources, which allows a nursing practitioner to find the best and most accurate information efficiently.

Professional Online Databases

Professional databases represent a source of online information that is generally invisible to all internet users except those with professional or academic affiliations, such as faculty, staff, and students. These databases, which range from specific to general, act as collection points by aggregating information, such as abstracts and articles from many journals. Two such databases include the **Cumulative Index to Nursing and Allied Health Literature (CINAHL)** and **MEDLINE**. CINAHL, for example, specifically includes information from all aspects of allied health, nursing, alternative medicine, and community medicine. The MEDLINE database contains references to more than 22 million journal articles and is maintained and produced by the National Library of Medicine.

PubMed comprises more than 30 million citations for biomedical literature from MEDLINE, life science journals, and online books. The **Cochrane Library** is a collection of databases in medicine and other healthcare specialties; its core is the collection of Cochrane Reviews, which is a database of systematic reviews and meta-analyses that summarize and interpret the results of medical research. Other databases such as **PsycInfo**; **PsycArticles**, which is a database of articles from journals published by the **American Psychological Association (APA)**; and the **Educational Resources Information Center (ERIC)** database may also benefit nursing. Many databases also offer full-text capabilities, meaning that entire articles are available online. The articles and abstracts contained within these databases have already withstood the rigors of publication in professional journals and therefore are considered viable and authentic peer-reviewed sources.

Libraries with subscriptions to databases often employ library professionals who are able to help patrons sift through the vast amounts of available electronic information; using the expert research capabilities of a health science librarian at one's local university is the best way to learn how to conduct database searches that yield the most efficient and useful results. Also useful are websites that provide tutorials on best searching practices specifically for medically oriented databases, such as the tutorials provided by EBSCO (an acronym for the Elton B. Stephens Company) to support searching the CINAHL database.

Search Engines

Search engines allow users to surf the web and find information on nearly anything, although many researchers steer clear of search engines because of the vast amounts of unsubstantiated information they are likely to uncover. Because no legitimacy needs to be provided for any information that appears on the web, an author can make claims, substantiated or not, and still use the web as a publishing venue. Despite the pitfalls associated with search engines

in general, they can yield a bounty of useful information when used with discretion.

Each search engine will produce results different from those produced by other search engines when used for the same research. For example, one popular search engine ranks its results by the number of hits that a page or site has received. Whereas the most popular research results are likely to be relevant, the order in which results appear does not indicate quality or viability of the source.

Web address (i.e., domain) suffixes (e.g., .com, .edu, .org, and .gov) indicate who is responsible for creating the website. Although a .edu site is hosted by an educational institution and for that reason may seem legitimate, consider that it could also belong to a student stating personal opinion, gossip, or guesswork. In contrast, .gov sites are maintained by the government and nearly always have professional contact information. Web hosts develop new domain suffixes constantly; therefore, although looking at the suffix can be useful, it should not be the sole deciding factor when choosing to trust information.

Information found on a web page should never be blindly trusted. When possible, check the date of the most recent update (How old is the page?), contact information (Is a bibliography or list of sources provided?), links to external sources (Do they seem relevant?), and previous attained knowledge from other reputable sources (Is the information too unbelievable?).

Fees and information retrieval charges should be approached with skepticism. Private companies do offer information aggregation services for a fee. In these cases, users pay a flat monthly fee for access to collections of articles in a particular field. What users (especially those affiliated with an academic institution) may not realize is that they are likely to have free access to the same, if not more complete, information through their institution's library system. Be sure to check with the medical librarian in a hospital system as well as the academic librarian in an educational institution.

Some legitimate databases and traditional newspapers that maintain a web presence do provide access for a small fee, but just as many other providers simply ask users to register to see articles

for free. Many nursing students and professionals affiliated with a university may find that their university library has already purchased access for the student body.

Electronic Library Catalogs

Nearly all higher education institutions have placed their library catalogs online. Although this is an obvious convenience for many students, some nursing professionals not used to working completely online may be intimidated by an e-catalog. Library professionals at the tiniest university and the busiest community college are available to demonstrate how to navigate a basic search of their library's catalog. Asking for assistance in learning how to access the vast assortment of journals, books, databases, and other resources available at one's college library is an excellent idea. Students in nursing programs at larger universities will likely find free classes that specifically teach users how to navigate and use the online catalog. If smaller colleges and universities do not offer these services, one should take advantage of the library's online tutorials, help pages, frequently asked questions pages, and online reference service (if available). Local public libraries often have subscriptions to popular databases and offer free classes on searching techniques to patrons, providing yet another free access point to the best information for one's research needs. Making full use of available library resources serves to strengthen information literacy skills, which enables learners to master content and extend their investigations, become more self-directed, and assume greater control over their own learning (ACRL, 2016).

Fair Use of Information and Sharing

Copyright laws in the world of technology are notoriously misunderstood. The same copyright laws that cover physical books, artwork, and other creative material apply in the digital world. Have you ever given a friend a flash drive that contains a computer game or some other type of software that you paid for and registered? Have you ever downloaded a song from the internet without paying for it? Have you ever copied a section of online content from a reference site and used that content as if it were your own? Have you ever copied a picture from the internet without asking permission from the photographer who took the picture? Have you ever copied and pasted information about a disease or drug from a website and then printed out the information to give to a patient or family member? All of these situations are examples of the type of copyright infringements enabled by technology that occur almost without thought.

The value of creative material—whether it is written content, a song, a painting, or some other type of creative work—lies not in the physical medium on which it is stored but rather in the intangibles of creativity, skills, and labor that went into creating that item. The person who created the material should be properly credited and possibly reimbursed for the use of the material. How would musicians be reimbursed for their music if everyone just downloaded their songs illegally from the internet? Imagine that you created a game to teach patients with type 1 diabetes how to manage their diet, and other nurses copied and distributed that game without getting your permission to do so. How would you feel?

Almost all software, music, and movies (either digital or in hard copy [CDs or DVDs] form) come with restrictions on how and why copies can be made. The license included with the software clarifies exactly which restrictions are applicable. The most common type of software license is a shrink wrap license, meaning that as soon as the user removes the shrink wrap from the CD or DVD case, they

have agreed to the license restriction. Most computer software developers allow for a backup copy of the software to be made without restriction. If the hard drive on the user's computer fails, the software can usually be reinstalled through this backup copy. Some software companies even allow the purchaser of a software package to transfer it to a new user. In this case, typically, the software must be uninstalled from the original owner's computer before the new owner is free to install the software on their computer. Most of these restrictions depend on the honesty of the user in reading and following the licensing agreement. As a result of widespread abuses, however, the music and film industries commonly include hardware security features in their products that block users from making a working copy of a music CD or movie DVD.

The bottom line is that copyright laws also apply to the digital world, and copyright violations can lead to prosecution. Advances in technology have made the sharing of information easy and extremely fast. A scanner can convert any document to digital form instantly, and that document can then be shared with people anywhere in the world. Nevertheless, the person who originally created that document has the right to approve of the sharing of the work. Carefully read the fine print of any software purchased, and be sure to clarify any questions regarding how that software can be copied. Avoid downloading music illegally from the internet, and do not use information from the internet without permission to do so or without citing the reference appropriately. Healthcare organizations that allow access to the internet from a network computer should ensure that users are well aware of and compliant with all copyright and **fair use** principles.

Informatics Tools for Collecting Data and Storing Information

As knowledge workers, nurses are already intimately familiar with data collection as they enter patient data in electronic health records (EHRs). As early as 1991, Werley et al. advocated for use of standardized data collection using the Nursing Minimum Data Set. Although these standardized nursing data sets comprise gathered information, such as healthcare definitions, classification systems, and nursing information, they were primarily used to support patient care and not for research.

Nurses have traditionally generated and recorded data from their own observations or with the assistance of various devices. Free text (i.e., informational data, such as drug dosages administered, resources used, and problems diagnosed) is recorded electronically. Free text is then interpreted and organized by some standardizing principle, either manually or by computer. In this way, data (often qualitative data that cannot be traditionally measured in a numeric sense) can be organized and processed. A central issue to the generation and analysis of free-text data is the lack of a generally accepted set of terminology to capture nursing data.

Knowledge networks are rich and dynamic digital collections affording high-quality knowledge support to their users for sharing, developing, and evolving knowledge. Knowledge networks include linked users of research collaborations. The nurses as users of the knowledge network should assess the knowledge base and determine the extent to which the network is generating new knowledge or recycling current knowledge to facilitate new insights.

Database management systems consist of software designed to collect, sort, organize, store, retrieve, select, and aggregate data. Nursing and health data may be classified into four basic types: (1) resource data (e.g., financial information), (2) patient and client demographics, (3) activity data (i.e., clinical data), and (4) health

service provider data. These primary data may be either recorded manually or collected electronically, with manual collection providing a greater opportunity for error. The process of electronically recording data follows a programmed set of instructions built into the software, thereby substantially cutting down on collection error. Of paramount importance in the collection process are the data collection form and the computer interface used for inputting the data, both of which affect the completeness, consistency, and accuracy of the resulting data (Brackett, 2015).

Quantitative data collection tools, or instruments, include questionnaires, interviews, surveys, quizzes, assessments, email interviews, and web-based surveys, all of which generate numerical rather than text-based data. Questionnaires—one of the most popular means of data collection—can be administered in hard copy form or programmed into a website where individuals may answer the questions electronically (Statistics Canada, 2016). Other electronic data collection tools include **handheld devices** and on-site laptops. A key benefit of using electronic data collection is the ability to directly transmit data to another computer for compilation and analysis, thereby cutting down on the risk of error (Kania-Richmond et al., 2016; Teale et al., 2013).

Of course, one must always be cognizant of the need to protect the privacy of participants by de-identifying data collected for research and having tools in place to provide secure transmission and storage of private information. Some researchers are finding rich qualitative data on public and freely available patient support sites and blogs. An important issue associated with such internet-based data collection is whether participants actually are who they say they are and whether they actually have the variable of interest or are just pretending to be someone or something they are not. Remember that the same rules for protecting human subjects apply no matter where the data are accessed or collected, and all research involving human subjects should be formally approved by the appropriate institutional review board (IRB). Many IRBs have specific policies in place that govern electronic data collection and storage to

ensure that the rights and privacy of research participants are protected (Penn State Senior Vice President for Research, n.d.).

Harder-to-measure, nonnumerical qualitative data can be collected electronically in the form of a narrative, or diary-like, entry. Much in the way that free text is analyzed and sorted, this narrative dialogue is assessed and then coded to look for patterns and themes that represent the phenomenon under study. For example, a nurse researcher may be interested in studying the lived experiences of women recently diagnosed with breast cancer and therefore may ask them to keep a diary of their thoughts, questions, and treatment experiences.

The COVID-19 pandemic accelerated the commitment to collecting healthcare data in a standardized way to facilitate data sharing and treatment outcomes. As Eddy (2022) described, in response to the pandemic, the National COVID Cohort Collaborative (NC3) was formed, and biomedical researchers opted to use a common data collection model, the Observational Medical Outcomes Partnership (OMOP) Common Data Model (CDM). The Observational Health Data Sciences and Informatics (OHDSI) (n.d.) organization explains, "The Observational Medical Outcomes Partnership (OMOP) Common Data Model (CDM) is an open community data standard, designed to standardize the structure and content of observational data and to enable efficient analyses that can produce reliable evidence" (para. 1). The ability to easily share standardized healthcare data promotes descriptive analyses, research collaboration, public health surveillance, and predictive modeling (OHDSI, n.d.).

Tools for Processing Data and Data Analysis

Data analysis is the process by which data collected during the course of a study are processed to identify trends and patterns of relationships. Descriptive statistics allow the researcher to organize information meaningfully, thereby facilitating insight by describing what the data show. A range of tools exist to facilitate such analysis, including specialized databases; word processing, spreadsheet, and database applications; and statistical packages (Laitinen et al., 2014).

Quantitative Data Analysis

Quantitative data focus on numbers and frequencies, with the goal of describing a situation or looking for more robust relationships, such as correlations, and specific variable contributions to an outcome. This aim stands in contrast to qualitative analysis, which focuses on experiences and meaning. Although the kind of data generated by quantitative collection is fairly straightforward and easy to analyze (i.e., responses to questionnaires, experiments, and psychometric tests), quantitative data analysis has come under criticism. Psychologists, for example, prefer to use a combination of quantitative and qualitative data and to back up research participants' explanations with statistically reliable information obtained by numerical measurement (Holah.co.uk, n.d.).

In quantitative studies, variables represented by data are collected in numerical form. These values are then entered into specific fields that have predetermined meanings or are coded. Various quantitative data analyses can be applied to nursing research, such as intervention research, quality improvement studies, and outcomes research. One of the most popular statistical packages for this kind of analysis is the Statistical Package for the Social Sciences (SPSS). Depending on the research goal, the researcher may use different types of analysis. Statistical goals may require hypothesis testing,

model building, or descriptive and exploratory analyses. For example, hypothesis testing is based on assumptions regarding the relative truth of the hypothesis; therefore, a data analysis would compare actual outcomes with purported hypotheses.

Qualitative Data Analysis

Extremely varied in nature, qualitative data can include nearly any information that can be captured and is not numerical (Trochim, n.d.-a). Qualitative data are more concerned with describing meaning than with drawing statistical inferences; what is lost in reliability (e.g., faulty transcription or forgotten details) is gained in validity (Holah.co.uk, n.d.). Although qualitative data rely on judgments, they can still be manipulated numerically, much in the same way that quantitative data can be open to judgment (Trochim, n.d.-b).

Some major types of qualitative data include in-depth interviews, direct observation, and written documents. Interviews include individual and focus group interviews and may be recorded. Interviews differ from direct observation in their interactive nature. Direct observation differs from case to case and often means that the researcher does not make contact with the respondent. Written documents might include a variety of written materials, including memos, newspaper clippings, conversation transcripts, and books (Trochim, n.d.-a).

Data analysis is facilitated by computers and specialized programs, such as Excel, Access, or NVivo, in which a user can categorize data and link categories with key words. Data can be converted into information and knowledge by either inductive or deductive reasoning. Most qualitative methods use an inductive approach in which the researcher generates hypotheses (versus the deductive approach typical of quantitative studies, in which hypotheses are tested). Data analysis in quantitative studies may allow the researcher to make inferences to a population beyond the sample as long as the sample was representative of the population. In contrast,

generalizing to a larger population is not a goal of qualitative research. Rather, in qualitative research the goals are exploration and deeper understanding of a phenomenon that has not been widely studied (**Figure 21-2**).

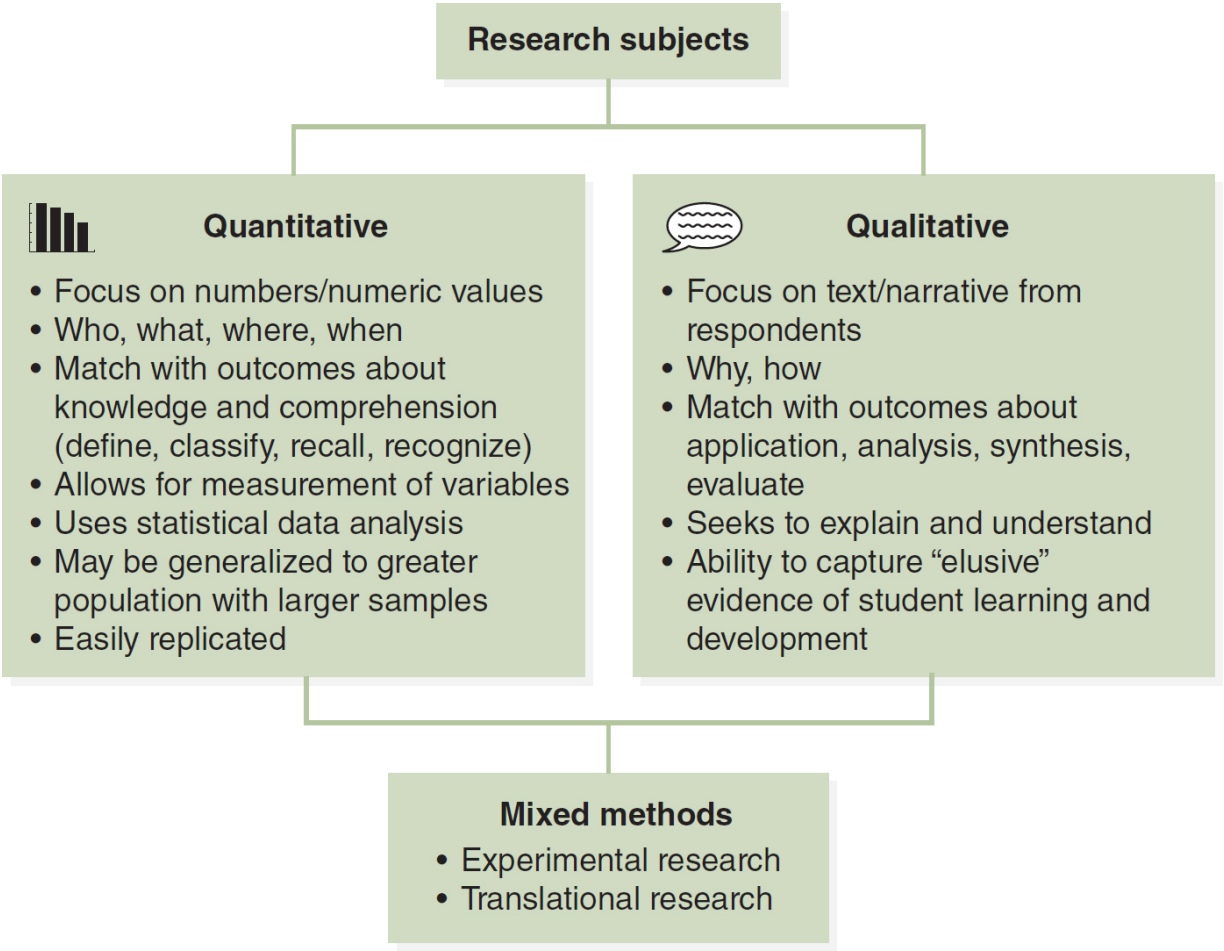


Figure 21-2 Quantitative Versus Qualitative Research

Description

Two relatively new approaches to quantitative research are cohort research and case control research. Cohort research is a type of study in which two groups of people are identified, one with an exposure of interest and another without the exposure. The two groups are followed to determine whether the outcome of interest occurs. Groups are defined based on whether they have had an exposure to a particular risk factor. In contrast, case control research

is a type of study in which patients who have an outcome of interest and patients who do not have the outcome are identified; the researcher then looks back in time (typically, using health records) to determine exposures and experiences that could have contributed to the outcome occurring or not occurring (Brown, 2014).

The copious amount of data collected in health care is useless if it cannot be analyzed to yield information and knowledge. **Big data** is a field that deals with ways to examine, analyze, and systematically extract data and information from data sets that are too large or complex to be processed using conventional data-processing application software. The big data revolution challenged healthcare professionals to meaningfully assess the data sets using technical advances to make it easier to collect and analyze information from multiple sources. In health care, data are blended from many sources, such as nurse-managed clinics, hospitals, payers, laboratories, free-standing imaging centers, and physicians' offices. The ability to aggregate this data using advanced data analytics to find better answers is changing the healthcare landscape and how nurses care for their patients.

The Future

The future of NI is growing as fast as technology itself. The more nurses participate in the development process of healthcare technology, the more efficient and effective NI may become. Nurses are urged to take an active role in the profession by providing real-world feedback during the design process and after implementation. Such practical insights will provide valuable data for technology evaluation and advancement in the field of NI.

Summary

This chapter discussed the value of information literacy as an essential research tool and its relationship to knowledge generation and lifelong learning. The reader is now acquainted with informatics tools useful for acquiring new knowledge and assessing previous knowledge and tools useful for collecting, storing, and analyzing information to generate knowledge. In an ideal world, information literacy and informatics tools would be used as a critical skill set for increasing healthcare efficiency, effectiveness, and safety in the 21st century.

THOUGHT-PROVOKING QUESTIONS

1. How does information literacy affect NI in the 21st century?
2. Provide a detailed description of how NI facilitates both qualitative and quantitative research.
3. Reflect on copyright law and why it is needed. Suppose you determine that photographs or other images can be replicated based on your assessment of fair use but your administrative assistant refuses to photocopy them because he feels that it is copyright infringement and against company policy. Describe in detail how you would handle this situation.
4. What is big data? How has NI affected data analytics in relation to large data sets?

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CHAPTER 22

Informatics-Based Research Processes: Data Mining and Artificial Intelligence

OBJECTIVES

1. Describe big data.
2. Appreciate the effect of artificial intelligence on knowledge discovery in clinical data.
3. Explore the contributions of data mining, computational biology, and bioinformatics.
4. Compare data analytics models.

KEY TERMS

- algorithm
- bagging
- big data
- bioinformatics
- biomedical informatics
- boosting
- brushing
- classification
- classification and regression tree (CART)
- computational biology
- data mining

- data set
- decision tree
- deep learning
- digital phenotyping
- drill down
- exploratory data analysis (EDA)
- machine learning
- meta-learning
- modeling
- multidimensional database
- neural network
- online analytic processing (OLAP)
- scoring
- Six Sigma
- stacking
- unstructured data

Introduction: Big Data, Data Mining, and Knowledge Discovery

The digital revolution in health care brought on by the shift to electronic health records (EHRs), interoperability initiatives, and increasingly sophisticated technology tools has led to the generation of large amounts of healthcare data. Although these data can seem overwhelming at times, they afford the opportunity to leverage data mining tools to convert them into actionable knowledge. Data mining methods have been developed over time using research. As data mining evolves, healthcare organizations have not only become able to navigate their data in real time but also have progressed beyond mere access to retrospective data to navigational improvements that allow them to learn much from their data. Using data mining techniques on data stored in an enterprise data warehouse, administrators could, for example, answer the question, "What was the most commonly diagnosed disease in our nine-hospital system last April?" They could then **drill down** to one hospital. As big data collection capabilities, data capture, data transmission, storage capabilities, powerful computers, statistics, artificial intelligence (AI), high-functioning relational database engines with data integration, and advanced algorithms developed, the ability to data mine big data to predict and deliver prospective and proactive information has been realized. By answering a question such as "What is likely to be the most commonly diagnosed disease next month and why?" predictions can be made. These actionable insights might then be used to inform professional recruitment or staffing strategies for the healthcare system. Data mining includes tools for visualizing relationships in the data and mechanizes the process of discovering predictive information in massive databases.

Pattern discovery entails much more than simply retrieving data to answer an end user's query. Data mining tools scan databases and identify previously hidden patterns. The predictive, proactive

information resulting from data mining analytics then assists with development of business intelligence, especially in relation to how an enterprise can be improved.

Building intelligence or knowledge is key; therefore, in 2013 the National Institutes of Health (NIH) Big Data to Knowledge (BD2K) initiative was launched to support the research and development of innovative and transformative approaches and tools to maximize and hasten the integration of big data and data science into biomedical research. The BD2K initiative supports initial efforts toward making data sets FAIR: findable, accessible, interoperable, and reusable. Although the BD2K program has concluded, it was responsible for advancing data sciences by individual training and the development of data analytics education resources, software, and data indices (NIH, 2021).

In response to the COVID-19 pandemic, the White House Office of Science and Technology Policy (2020) requested the development of an open-access machine-readable research data set. The COVID-19 Open Research Dataset (CORD-19)
is a collection of coronavirus literature formed as a result of the efforts of several groups, including a commercial software vendor, a university, an AI institute, the NIH, and the National Library of Medicine. "The White House joins these institutions in issuing a call to action to the Nation's artificial intelligence experts to develop new text and data mining techniques that can help the science community answer high-priority scientific questions related to COVID-19" (para. 3). This database provided a tremendous opportunity for scientific researchers to mine this valuable data, discover new insights, collaborate on strategies for addressing this pandemic, and prepare for and predict future pandemics.

Much of our big data are **unstructured data**; unstructured big data reside in text files, which represent more than 75% of an organization's data. Such data are not always contained in databases and can easily be overlooked; moreover, trends and patterns are difficult to discern in such data. **Data mining** is an iterative process that explores and models big data to identify patterns and provide meaningful insights. As the tools evolve with which data and

information can be collected, accessed, and processed, it is necessary to concomitantly evolve how the data and information are analyzed and interpreted.

A website article (Taylor, 2023) described **big data** as a collection of data that is huge in size and yet growing exponentially with time. In short, such a collection of data is so large and complex that none of the traditional data management tools are able to store it or process it efficiently (para. 2). Big data are generated every day from trades on the stock exchange; social media posts; graphics; videos; photographs; digital X-rays; cell phones; and even jet engines, which can generate millions of data points during each flight. Consider the amount of data generated from patient information gathered in a practice, all practices in any community, and all practices across any country. It is hard to even imagine how much data are processed.

Data mining is the process of using software to sort through data to discover patterns and ascertain relationships. This process may help to discover previously unidentified relationships among the data in a database with a focus on applications. This information can then be used to increase profits or decrease costs or both. In health care, data mining is being used to improve efficiency and quality, which results in better healthcare practices and improved patient outcomes.

As healthcare professionals' analytical skills are honed, they will be able to clarify and explain patterns in healthcare big data related to improved patient responses to select treatments for optimal patient outcomes. They can then drill down for each treatment to examine the conditions patients presented with and the number of visits they made. The data can then be explored to refine the output. For example, it would be very important to know more about patients, such as whether they had other conditions or diseases (i.e., comorbidities), as well as their age, gender, and educational level, which could affect their outcomes. Zarrinpar et al. (2019) have identified EHR big data research as comparative effectiveness research used to explore the effectiveness of treatment approaches. "The patient populations are very large and more representative of

actual practice; the comparators are active and variable; outcome measures are patient centered or global; follow-up time is long; cost is low, especially per patient; and the speed is fast" (p. 602).

Data mining projects help organizations discover interesting knowledge. These projects can be predictive, exploratory, or focused on data reduction. Data mining focuses on producing a solution that generates useful forecasting through a four-phase process: (1) problem identification; (2) exploration of the data; (3) pattern discovery; and (4) knowledge deployment, or application of knowledge to new data to generate predictions. Data mining is an analytical, logical process with the ultimate goal of forecasting. It unearths concealed predictive information to help construct a picture of the data that lends insight into future trends, actions, or behaviors. This data exploration and resulting knowledge discovery foster proactive, knowledge-driven decision-making. See **Figure 22-1**, which illustrates how raw data are transformed into knowledge through an iterative and interactive process.

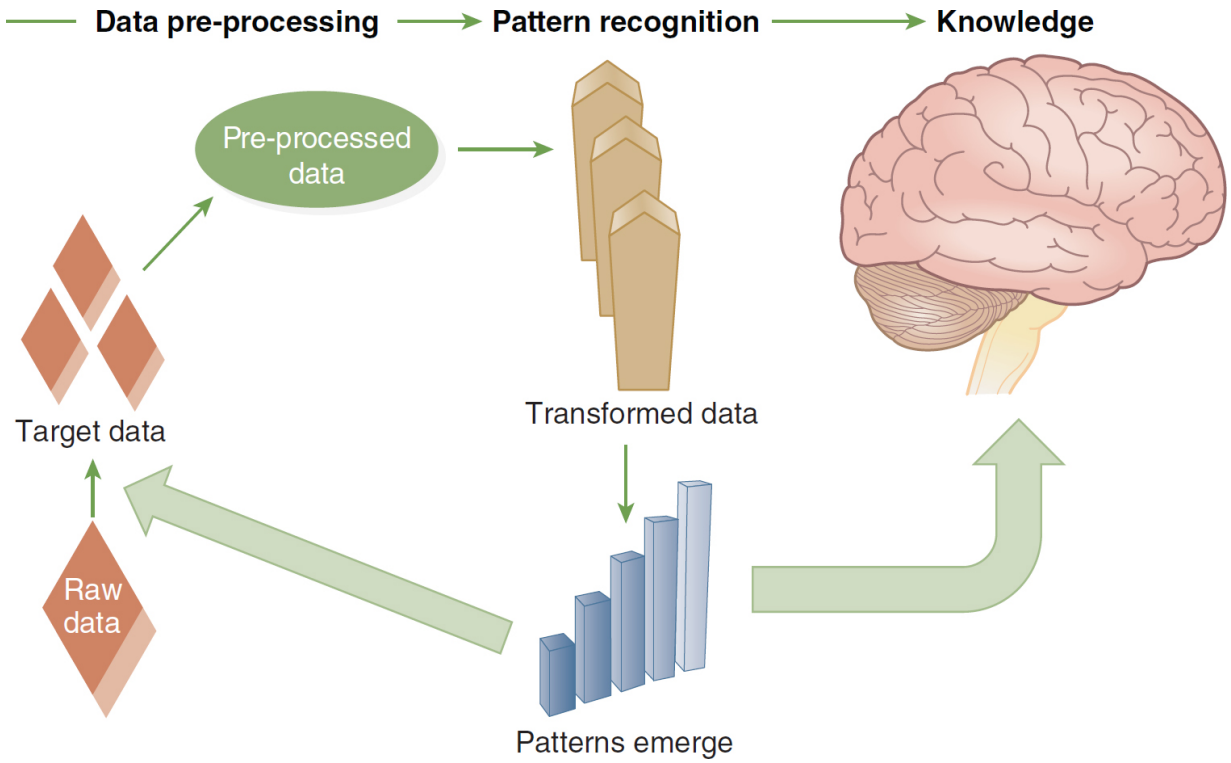


Figure 22-1 Transforming Raw Data into Knowledge through an Iterative and Interactive Process

Image created by Dr. Dee McGonigle.

Description

The steps in the data mining process have been variously described. We outline some of the key components of the process here.

Problem identification is the initial phase of data mining. The problem must be defined, and everyone involved must understand the objectives and requirements of the data mining process they are initiating.

Exploration begins with exploring and preparing the data for the data mining process. This phase might include data access, cleansing, sampling, and transformation; based on the problem to be solved, data might need to be transformed into another format. To assure meaningful data mining outcomes, the data must truly be comprehended. The goal of this phase is to identify the relevant variables and determine their nature.

Data are mined using models. According to Microsoft (2022), mining models are generated when "an algorithm [is applied] to data, but it is more than an algorithm or a metadata container: it is a set of data, statistics, and patterns that can be applied to new data to generate predictions and make inferences about relationships" (para. 1). It is important to consider the data mining structure and the model as two discrete objects. The data mining model remains empty until the data from the data mining structure have been processed and examined. The data mining structure stores information that defines the data source. The data mining model stores information that results from the statistical processing of the data, such as patterns arising from the examination or analysis. After a data mining model has been processed, it will contain metadata; outcomes; and bindings, or links back to the data mining structure.

Sometimes known as model building or pattern identification, pattern discovery is a complex phase of data mining. In this phase,

different models are applied to the same data to choose the best model for the data set being analyzed. It is imperative that the model chosen should identify the patterns in the data that will support the best predictions. The model must be tested, evaluated, and interpreted. Therefore, this phase ends with a highly predictive, consistent pattern-identifying model.

The final phase, knowledge deployment, takes the pattern and model identified in the pattern discovery phase and applies them to new data to test whether they can achieve the desired outcome. In this phase, the model achieves insight by following the rules of a decision tree to generate predictions or estimates of the expected outcome. This deployment provides the organization with the actionable information and knowledge necessary to make strategic decisions in uncertain situations.

Data mining develops a model that uses an algorithm to act on **data sets** for one situation where the organization knows the outcome and then applies this same model to another situation where the outcome is not known—an extension known as **scoring**. Data mining is concerned with extracting what is needed. It applies statistics so that organizations can gain an advantage by manipulating information for practical applications. In the information-overloaded healthcare world, all too often health practitioners find themselves grasping for knowledge that is currently nonexistent or fleeting. Data mining is a dynamic, iterative process that is adjusted as new information surfaces. It is a robust, predictive, proactive information and knowledge tool that, when used correctly, empowers organizations to predict and react to specific characteristics of and behaviors within their systems.

Data mining is also known as knowledge discovery and data mining (KDD), knowledge discovery in data, and knowledge discovery in databases. The term *knowledge discovery* is key because data mining looks at data from different vantage points, aspects, and perspectives and brings new insights to the data set. This analysis sorts and categorizes the data and then summarizes the relationships identified. In essence, data mining is the process of finding correlations or patterns among the data.

Health care, as noted earlier, generates big data. In turn, data mining tools are able to analyze enormous databases to determine patterns and establish applications to new data. Healthcare organizations clearly need to invest more in big data and data mining analysis if they are to have an effect on clinical outcomes and population health. Vennaro (2017) lamented the shortage of health informaticists:

> *There are currently fewer than 15,000 formally trained medical informaticists in the U.S., with demand increasing up to 70,000 in the next five years [2022]. This creates a huge talent gap, where healthcare organizations lack the clinical expertise required to make data effective. Without informaticists to bridge the business and clinical aspects of data, it will be difficult for organizations to ask the right questions, let alone getting to the right actions and conclusions.* (para. 6)

The healthcare sector has discovered data mining through the realization that knowledge discovery can help to improve healthcare policy making and practices, disease prevention, detection of disease outbreaks, prevention of sequelae, and prevention of in-hospital deaths. On the business side, healthcare organizations use data mining for the detection of fraudulent insurance claims. According to Kumaraswamy et al. (2022),

> *Healthcare fraud is an expensive, white-collar crime in the United States, and it is not a victimless crime. Costs associated with fraud are passed on to the population in the form of increased premiums or serious harm to beneficiaries. There is an intense need for digital healthcare fraud detection systems to evolve in combating this societal threat.* (para. 1)

If organizations are to develop a successful data mining process, they must have specially trained data analysts (also called biomedical informaticists) and access to the data needed to create meaningful information. In general, there are three main types of data analytics, each with a different objective: descriptive analytics to gain information on what has occurred, predictive analytics to suggest what might occur, and prescriptive analytics to suggest a course of action (University of Pittsburgh, 2021).

In health care, the ability to analyze the data by making sure that those data are comprehensive and complete, meeting current needs,

and cleansed and prepared for the data mining process is being honed. Many facilities are using data warehouses to store data and facilitate this pre–data mining process. In addition, healthcare systems are increasingly sharing data to build robust databases and to share best practices. Nurses are learning to ask the right questions during the data mining process to gain a thorough understanding of their data. The following pages introduce the concepts, techniques, and models used in data mining.

Knowledge Discovery and Data Mining and Research

Data mining for knowledge discovery is not new; it has been used for several decades in research. Over the past several decades, the KDD capability has improved as the analytical power of data mining tools has increased, thereby facilitating the recognition of patterns and relationships in big data. Berger and Berger (2004) have suggested that nurse researchers are positioned to use data mining technologies to transform the repositories of big data into comprehensible knowledge that will be useful for guiding nursing practice and facilitating interdisciplinary research.

Knowledge discovery capabilities continue to evolve because of the availability of advanced analytical software that is designed to facilitate data mining. Early examples of data mining in research include Goodwin et al. (1997), who explored the relationship between clinical data and adult respiratory distress syndrome (ARDS) in critically ill patients. Madigan and Curet (2006) described the **classification and regression tree (CART)** data mining method for analyzing the outcomes and service use in home health care for three conditions, chronic obstructive pulmonary disease, heart failure, and hip replacement. They found that four factors—patient age, type of agency, type of payment, and ethnicity—influenced discharge destination and length of stay. Trangenstein et al. (2007) described how faculty members used data mining to analyze their students' clinical logs, which enabled them to make programmatic decisions and revisions and rethink certain clinical placements. Fernández-Llatas et al. (2011) described workflow mining technology as a means to facilitate relearning in dementia processes. Lee et al. (2011) discussed the application of data mining to identify critical factors such as nursing interventions related to patient fall outcomes. Lee et al. (2012) used data mining to determine risk factors related to each stage of pressure ulcers and

identified five predictive factors: hemoglobin level, weight, sex, height, and use of a repositioning sheet. Based on the results of this data mining analysis, nurses can better target their interventions to prevent pressure ulcers. Green et al. (2013) identified differences in limb volume patterns in breast cancer survivors; their results have the potential to influence clinical guidelines for the assessment of latent and early-onset lymphedema.

More recent data mining research reports highlight the versatility of clinical problem-solving afforded by data mining. Li et al. (2019) explored factors that predict pressure injuries for patients at the end of life; De Gagne et al. (2019) mined Twitter data to uncover cyberincivility between nurses and students; Thorlton and Catlin (2019) mined data to uncover adverse drug events; Härkänen et al. (2020) studied staffing and medication errors; Jin (2022) used data mining to predict risks in obstetric nursing; and Chen (2021) described data mining techniques for optimizing a nursing management system. Interprofessional collaboration and its effects on patient outcomes is also receiving more attention in the research literature. Conca et al. (2018) described a process mining approach to examine collaborations within the care team in the treatment of patients with type 2 diabetes.

As these research examples suggest, data mining is a powerful tool with nearly endless possibilities for informing and supporting clinical transformations using data-driven models of care and examining interprofessional collaboration to reduce inefficiencies, control costs, and improve quality.

CASE STUDY

In a large teaching hospital, patients with congestive heart failure (CHF) who are being treated at the facility have a high rate of readmission. The chief nursing officer (CNO) wants to know the cause of the readmissions because the rate at this facility is almost twice that of competing healthcare entities in the area. The CNO works with the nursing researchers at the university to address this situation.

The researchers begin to scour the EHRs of more than 15,000 CHF hospitalizations in the past 4 years to determine the cause of the situation. As they begin to understand this data set, they are able to build a data mining model using algorithms to discover patterns and relationships in the data. Based on the old data, they determine that the key factor for readmission was the length of time it took to follow up at home with discharged patients.

In response to this new knowledge, a program is developed in which nurses telephone patients with CHF the day after their discharge, and a home visit is scheduled for the second day post discharge to ensure a smooth transition to home or an assisted living facility. The follow-up within the first 4 days of discharge has reduced readmissions by 40%. The model that was used with the old data is being applied to the new data.

CASE STUDY: 23ANDME

One of the largest genetic studies of our time could be 23andMe. According to Molteni (2018), "Since the launch of its DNA testing service in 2007, genomics giant 23andMe has convinced more than 5 million people to fill a plastic tube with half a teaspoon of saliva" (para. 1). So what do the customers receive? Molteni stated that "[i]n return for all that spit (and some cash too), customers get insights into their biological inheritance, from the superficial—do you have dry earwax or wet?—to mutations associated with disease" (para. 1). "What 23andMe gets is an ever-expanding supply of valuable behavioral, health, and genetic information from the 80 percent of its customers who consent to having their data used for research" (para. 1). Therefore, this company captures and gains access to big data that it can mine. It can also sell the mining rights: "[O]ne of the world's biggest drugmakers, GlaxoSmithKline, is gaining exclusive rights to mine 23andMe's customer data for drug targets" (para. 1). It will have "four years of exclusive rights to run analyses to discover new drug targets" (para. 2). Reflecting on this information, what effect could businesses have on the healthcare market if they can leverage big data from patients and consumers?

Molteni, M. (2018). *23andMe's pharma deals have been the plan all along.* Wired. www.wired.com/story/23andme-glaxosmithkline-pharma-deal

Businesses have also gathered healthcare data. In some cases, the big data that they garner is used to leverage more investments into their companies. One example is 23andMe. Think about the

capture and sale of big data mining rights while you refer to the 23andMe case study.

Data Mining Concepts

Bagging is the term that describes the use of voting and averaging in predictive data mining to synthesize the predictions from many models or methods or the use of the same type of model on different data. This term can also refer to the unpredictability of results when complex models are used to mine small data sets.

Boosting is what the term infers—a means of increasing the power of the models generated by weighting the combinations of predictions from those models into a predicted **classification**. This iterative process uses voting or averaging to combine the different classifiers.

Data reduction shrinks large data sets into manageable, smaller data sets. One way to accomplish this is via aggregation of the data, or clustering.

Typically, drill down analysis begins by identifying variables of interest to drill down into the data. Nurses could identify a diagnosis and then drill down, for example, to determine the ages of those diagnosed or the number of males. They could then continue to drill down and expose even more of the data.

Exploratory data analysis (EDA) is an approach that uses mainly graphical techniques to gain insight into a data set. Its goal varies based on the purpose of the analysis, but it can be applied to the data set to extract variables, detect outliers, or identify patterns.

Feature selection reduces inputs to a manageable size for processing and analysis whereby the model either chooses or rejects an attribute based on its usefulness for analysis.

Machine learning is a subset of AI that permits computers to learn either inductively or deductively. Inductive machine learning is the process of reasoning and making generalizations or extracting patterns and rules from huge data sets—that is, reasoning from a large number of examples to a general rule. Deductive machine learning moves from premises that are assumed true to conclusions that must be true if the premises are true.

Meta-learning combines the predictions from several models. It is helpful when several models are used in the same project. The predictions from the different classifiers can be included as input into the meta-learning. The goal is to synthesize these predicted classifications to generate a final, best-predicted classification, which is a process also referred to as **stacking**.

Predictive data mining identifies the data mining project as one with the goal of identifying a model that can predict classifications.

Stacking or stacked generalization synthesizes the predictions from several models.

Data Mining Techniques

Many data mining projects are implemented as part of a team, with each member bringing important skill sets to the mix. For example, there may be a chief nursing informatics officer, a nurse informaticist, a statistician, and an information technology specialist. It is also important to identify the project goals and to choose the best technique to get the most from the data mining. As Simpson (2019) pointed out, "[o]ne of the most crucial skills for nursing's big data scientists will be the ability to frame questions specifically in order to derive not just a high-value answer but the insights that go with it" (p. 378). Following is an overview of the commonly used techniques in data mining neural networks, decision trees, rule induction, algorithms, and the nearest neighbor method.

Neural networks represent nonlinear predictive models. These models learn through training and resemble the structure of biological neural networks; that is, they model the neural behavior of the human brain. Computers are fast and can respond to instructions repeatedly. Humans use their experiences to make generalizations about the world around them. Neural networks are a way to bridge the gap between computers and humans, and they go through a learning process on existing data so that they can predict, recognize patterns, or classify data.

A **decision tree** is so named because the sets of decisions form a tree-shaped structure. The decisions generate rules for classifying a data set. CART and chi-square automatic interaction detection (CHAID) are two commonly used types of decision tree methodologies. See **Box 22-1** and **Figure 22-2** for an overview of decision tree analysis.

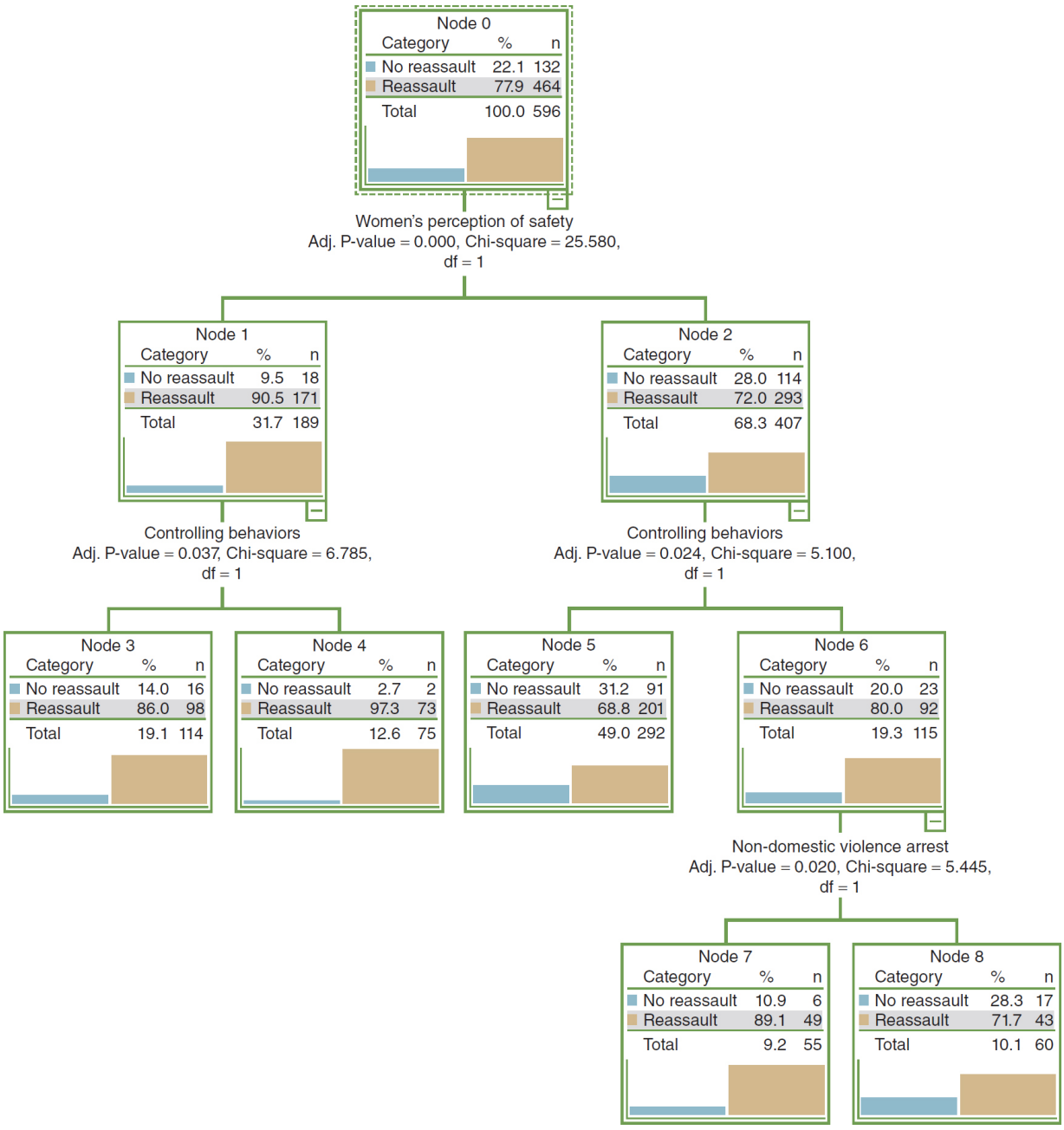


Figure 22-2 Decision Tree Analysis Output

Description

BOX 22-1 DECISION TREE ANALYSIS

Steven L. Brewer Jr.

Decision trees are a statistical technique based on using numerous algorithms to predict a dependent variable. These predictions are determined by the influence of independent variables. Decision trees help researchers understand the complex interactions among variables generated from research data. The entire data set is split into child nodes based on the effect of the independent predictors. The most influential variable is situated at the top of the tree; the subsequent nodes are ranked by the significance of the remaining independent predictors.

Graphically, decision trees produce a tree (as illustrated in Figure 22-2), which consists of a root node and child nodes. The tree is an inverted, connected graphic. The graphic representation of the decision tree helps general users, such as practitioners, understand the complex interrelationships between the independent and the dependent variables in a large data set.

Within the graphical display, there are three major components: the root node, the child nodes, and the terminal node. The root node represents the dependent variable, and the child nodes represent the independent variables. The root node is essentially the base of the tree, or the top node. It contains the entire sample, whereas each child node contains a subset of the sample within the node directly above it. In Figure 22-2, the root node represents a sample of women who were either reassaulted or not reassaulted in a domestic violence database. Data in the root node are then partitioned and passed down the tree.

The number of child nodes will vary depending on the classification procedure that is used to determine how the data are split. In Figure 22-2, the first child node is "women's perception of safety." This node suggests that the most influential predictor in domestic violence reassault for this sample is the women's perception of safety. The tree produces additional child nodes based on the responses to that variable. Node 1 represents the women who responded no when asked whether they felt safe in the relationship. For this node, women had a 90% chance of being reassaulted. In contrast, node 2 represents the women who responded yes when asked whether they felt safe in the relationship. These women had only a 72% chance of being reassaulted.

The decision tree in Figure 22-2 splits the entire sample into subsamples, which in turn allow for different predictions for different groups within the sample. For example, women who felt safe in their relationship (node 2) and experienced controlling behaviors (node 6) had an 80% chance of being reassaulted. In contrast, women who did not feel safe (node 1) and were in a relationship characterized by controlling behaviors (node 4) had a 97.3% chance of being reassaulted. The splitting of the data continues until the data are no longer sufficient to predict the remaining variables or there are no additional cases to be split.

Classification trees share commonalities with nonlinear traditional methods, such as discriminant analysis, cluster analysis, nonparametric statistics, and nonlinear estimation; however, the technique differs significantly from linear analyses. In general, the decision tree technique does not rely on "multiplicative" or "additive" assumptions, such as regression, to predict the outcome of *y*. The flexibility of classification trees is one characteristic that makes them attractive to researchers. The trees are not limited to examining all predictor variables simultaneously. Therefore, each predictor variable can be examined as a singularity to produce univariate splits in the tree. In addition, classification trees can handle a mixture of categorical and continuous variables when univariate splits are used. Although this flexibility offers advantages over traditional methods, classification trees are not limited to univariate splits.

Decision trees have become a popular alternative to methods such as regression and discriminate analysis for data mining big data. Such trees use algorithms from one of the numerous classification procedures to separate the data into different branches, or child nodes, that predict *y*. The dependent variable (*y*) is represented by the root node.

These algorithms have three main functions: (1) They explain how to separate or partition the data at each split, (2) they decree when to stop or end the splitting of data, and (3) they determine how to predict the value of *y* for each *x* in a split. The child nodes are separated into homogeneous groups by the algorithms from different classification procedures. This process of partitioning is the main purpose of classification procedures. First, the procedure clusters and creates child nodes. Second, it ranks them based on their predictive values of *y*. Hence, the most influential variables will be located at the base of the tree. From this point, the classification procedures further expand the child nodes by finding the next best factor. The tree is expanded until the algorithm is unable to find a clearly distinguishable split within the data.

Based on the results of the sample decision tree analysis presented in Figure 22-2, practitioners would conclude that women should be attuned to their perception of safety in a relationship because those who feel unsafe have a much higher chance of being reassaulted.

Decision trees are a powerful tool that can be used to mine large data sets and discover previously unknown relationships among the data. The predictive relationships uncovered by the decision tree analysis may be useful in directing approaches to future care interventions.

Rule induction is based on statistical significance. Rules are extracted from the data using *if-then* statements, which become the rules.

Typically, algorithms are computer-based methods with which data mining models are developed. To create the model, the data set is first analyzed by the algorithm to determine specific patterns and trends. Based on the results of this analysis, the algorithm defines the parameters of the data mining model. The identified parameters are then applied to the entire data set to mine it for patterns and statistics.

Nearest neighbor analysis classifies each record in a data set based on a select number of its nearest neighbors. This technique is also known as the *k*-nearest neighbor.

Text mining for text is equivalent to data mining for numerical data. Because text is not always consistent in health care, owing to the lack of a generally accepted terminology structure, it is more difficult to analyze. Text documents are analyzed by extracting key words or phrases.

Online analytic processing (OLAP) generates different views of the data in **multidimensional databases**. These perspectives range from simplistic views, such as descriptive statistics, frequency tables, or comparative summaries, to more complicated analyses that require various forms of cleansing the data, such as removing outliers. OLAP is also known as fast analysis of shared data.

Brushing is a technique in which the user manually chooses specific data points or subsets of data on an interactive data display. These selected data can be visualized in two- or three-dimensional surfaces as scatterplots. Brushing is also known as graphical exploratory data analysis.

Data Mining Models

To generate predictions and infer relationships, the data set, statistics, and patterns identified in existing data must be applied to new data. A data mining model is developed by exercising more than algorithms on data. Specifically, the data mining model consists of a mining structure plus an algorithm. The data mining model remains empty until it applies the algorithm or processes and analyzes the data provided by the mining structure. This model stores the information obtained from a statistical analysis of the data, identifies patterns, and gains insights. It then contains metadata that specify the name and definition of the model, the server location or other place where it is stored, definitions of any filters applied when processing the model, columns from the mining structure that were used to build the model, and the algorithm used to analyze the data. The columns and their data types, any filters, and the algorithm used are choices that are made in the data mining process, and each of these decisions can greatly influence the data mining results. The same data can be used to create many models; one type of model could organize the data into trees, for example, whereas another type of model might cluster the data in groups based on the rules applied. Different results can be achieved from the same mining structure, even though it is used in many models, based on the filtering method or analysis conducted. Therefore, each decision made along the way is very important.

There are many models. In this chapter, the following models will be reviewed: cross-industry standard process for data mining (CRISP-DM), Six Sigma, and SEMMA (sample, explore, modify, model, assess).

CRISP-DM

The CRISP-DM model follows a series of steps to develop a business understanding by gaining an understanding of the business data

collected and analyzed. The six steps are business understanding, data understanding, data preparation, modeling, evaluation, and deployment.

The CRISP-DM model begins with an understanding of the business. The situation must be assessed to establish the data mining goals and produce the project plan. The following questions must be answered: What are the business objectives? What are the requirements? Has the problem been specifically defined? The answers to these questions help transform the business perspective knowledge into a data mining problem definition and initial plan to meet the objectives.

Data understanding begins with the preliminary data collection and assimilation of the data. During this step, the data will be described and explored to facilitate the user's comprehension of the data. As the user gains familiarity with the data, data quality issues are identified, and the quality of the data is verified.

The data are cleansed and transformed during the data preparation step. First, one must select the data, attributes, and records to be used. These data are then cleansed, constructed, integrated, and properly formatted. At this point, the final data set is constructed from the data, and this data set will be processed by the model.

Modeling involves selection of the modeling methods and their application to the prepared data set. Parameters are calibrated, a test design is generated, and the model is built and assessed. This step might require that data preparation be revisited if the format of the data does not meet the specific requirements of the methods.

During the evaluation step, the degree to which the objectives were met is assessed from a business perspective. A key question is, Were any important business issues not considered? The model was built for high-quality data analysis. To see whether this goal has been met, the process is reviewed, the results are evaluated, and the model is interpreted. This is where the determination is made as to whether the model should be implemented or more iterations must occur before its deployment. The project may not be completed, or a new data mining project might be initiated. If the

project is deployed, this step is when the decision must be made as to how the results from the data analysis will be used.

Deployment is the final step, in which the model is finally implemented. The plan must be monitored and maintained and the project reviewed. The six-step process should yield a reliable, repeatable data mining process. The knowledgeable insights gained from the implementation of the model must be organized and presented in such a way that they can be used. The final project report is generated to document the process and share this enhanced knowledge of the data.

The CRISP-DM model employs a process that has been proven to make data mining projects more rapid and effectual. Using this model helps to avoid typical mistakes while assessing business problems and detailing data mining techniques.

Six Sigma and Lean

Six Sigma and Lean are data-driven methods to eliminate defects, avoid waste, or assess quality control issues. Although Six Sigma and Lean are often considered in tandem, only Six Sigma will be discussed here. **Six Sigma** aims to decrease discrepancies in business and manufacturing processes through dedicated improvements. It uses the DMAIC steps: define, measure, analyze, improve, and control.

The first step defines the goals of the project or for improvement. During this step, data mining techniques can be used to discover prospective ideas for implementing the project.

In the measure step, exploratory and descriptive data analyses are used on the existing system to enhance the understanding of the data. Reliable, valid, and accurate metrics with which to measure goal achievement in each of the steps are identified.

The analysis step should assess the system to identify discrepancies between the current big data and the goal. Statistical methods guide this analysis.

Improvements must be made to the current system to attain the organizational goals. The use of project management skills facilitates the application of the new methodology and processes. Statistical methods assess the improvements and any deficiencies that exist.

The final step of the model is control. Controlling the system is important so that discrepancies are remedied before they cause a disruption.

The Six Sigma model applies a different mentality to the same old business model or way of thinking. Typically, the DMAIC steps that are implemented result in success.

SEMMA

According to SAS (n.d.), "[t]he acronym SEMMA—sample, explore, modify, model, assess—refers to the core process of conducting data mining" (para. 1). This model is similar to Six Sigma but emphasizes the technical activities typically involved in data mining.

The first step is to sample the data. Sampling is optional but creates a more robust data mining effort. Using "[a] statistically representative sample of your data, SEMMA makes it easy to apply exploratory statistical and visualisation techniques, select and transform the most significant predictive variables, model the variables to predict outcomes, and confirm a model's accuracy" (SAS, n.d., para. 1). Creating a target data set shrinks the data to a manageable size yet maintains the important information necessary to mine.

The exploration of the data seeks to discover discrepancies, trends, and relationships in the data. It is at this point that ideas about the data should emerge to help the organization understand the data and their implications for the organization's business. In health care, for example, it would be important to determine how many people use the emergency department each year and how many of those people are admitted and released and then return and to identify any disparities in care and diagnoses. What was

discovered? What are the trends and relationships that emerge from the data mining?

After exploring, the data should be modified based on the information discovered. It might be important to modify the data based on groupings, such as "all people who are diagnosed with congestive heart failure who present with shortness of breath" if the trending and relationships indicate that this subgroup is significant. Other variables can also be introduced at this time to help gain a further understanding of the data.

The data are modeled to predict outcomes based on analytically searching the data. Combinations of data must be identified to predict desired outcomes.

During the assessment phase, the data, as well as the models, are assessed not only for the reliability of the discoveries but also for the usefulness of the data mining process. Assessment is key to determine the success of the data mining approach.

SEMMA focuses on the tasks of modeling. This approach has been praised for its ability to guide the implementation of data mining. Conversely, it has been criticized for omitting the critical features of the organization's business. SEMMA is logical and can be robust from sampling through assessment.

Based on the needs of the organization, a variety of models can be used in combination. A coordinated, cooperative environment is necessary for complicated data mining projects because they require organizational commitment and cooperation among researchers to ensure their success. As described in this section, models, such as CRISP-DM, Six Sigma, and SEMMA, have been designed as blueprints to deal with the dilemma of how to integrate data mining techniques into an organization. They facilitate the gathering of data and their analysis and conversion of the data into information and its dissemination in a format that is easy to understand to inform organizational decision-making. It is imperative that the results of the data mining process be implemented and any resultant improvements are monitored and evaluated.

The data mining field and processes are continuing to evolve. Here are some recent examples of models and algorithms that have

been employed to mine complex healthcare data. Singh and Ghalib (2021) described the development and use of a knowledge-based mining and linear analysis model (KB-LA), Klochko et al. (2022) described the use of machine learning with regression analysis in their data mining project, and Nomura et al. (2021) described the use of the Applied Healthcare Data Science Framework to develop a predictive pain management framework. These authors believe that we can expect these data mining models and algorithms to be increasingly shared in a collaborative effort to improve health care.

Benefits of Knowledge Discovery and Data Mining

KDD can enhance the business aspects of healthcare delivery and help to improve patient care. Examples of how KDD can be applied effectively follow:

- A durable medical equipment company analyzed its recent sales and enhanced its targeting of hospitals and clinics that yielded the highest return on investment.
- Several plastic surgery suites were bought by the same group of surgeons. They wanted to know how those organizations were the same and how they were different. They ran analytics for disparities and identified patterns and trends that led them to develop standardized policies and modify treatment plans.
- Analytic techniques were used in the clinical trials of a new oral contraceptive to aid in monitoring trends and disparities.
- Hidden patterns and relationships between death and disease in selected populations can be uncovered.
- Government spending on certain aspects of health care or specific disease conditions can be analyzed to discover patterns and relationships and distinguish between the real versus the desired outcomes from the investment.
- Patient data can be analyzed to identify effective treatments and discover patterns or relationships in the data to predict inpatient length of stay.
- Data can be analyzed to help detect medical insurance fraud.

Even though KDD can be complex, it tends to yield a potent knowledge representation. As analytics evolve, KDD will almost certainly become easier to use and more efficient and effective in facilitating data mining in health care.

Data Mining and Electronic Health Records

As EHRs become more prevalent, the data contained therein can be mined for many clinical and organizational purposes. It has already been established that the use of data-driven decision-making in patient care is supported by sophisticated EHR functions, such as clinical decision support and clinical pathways. Looking beyond the management of individual patient health care, however, it can be seen that EHR data mining can help with managing population health, informing administrative processes, providing metrics for quality improvement, supporting value-based reimbursement, and providing data for registry software that helps with population health management.

Registries are also being used to identify care gaps in patient populations in a physician's practice or other healthcare organization. An article on the Medical Economics (2015) website explained that some EHRs have a built-in registry function, whereas others interface with third-party registries. Registries are designed to do the following:

- Provide lists of subpopulations, such as patients with hypertension and diabetes
- Identify patients with care gaps, based on evidence-based guidelines
- Support outreach to patients who have care gaps
- Provide feedback on how each physician is doing on particular types of care, such as the percentage of their diabetic patients who have their HbA1c levels or blood pressure under control
- Generate quality reports for the practice (para. 17)

Another type of clinical data mining designed to improve patient outcomes is a retrospective look at clinical data in an EHR, known as temporal event analysis (Gotz et al., 2014). As Gotz et al. explained,

> *[o]ur approach consists of three key components: a visual query module, a pattern-mining module, and an interactive visualization module. We combine these three technologies together within a single framework that enables ad hoc event sequence analysis. With this capability, users are able to discover patterns of clinical events (e.g., sequences of treatments or medications) that most impact outcome. Moreover, our approach allows users to better understand how those associations change as patients progress through an episode of interest.* (p. 150)

In addition, data in an EHR can be used for administrative process improvement. Rojas et al. (2016) conducted a literature review on administrative process mining. Process mining is a relatively new use of data generated in hospital information systems and is dependent on event logs generated in the system.

Milinovich and Kattan (2018) described a process used by one prominent midwestern hospital to create research-ready data tables extracted from its EHR system. They used the Unified Medical Language System (UMLS) identifiers to map disparate EHR variables. "By mapping as many variables as possible to UMLS identifiers, a simplified data structure can be implemented to store and query the EHR data. Because the UMLS combines many disparate medical vocabularies into succinct terms, queries become simpler yet more robust with the UMLS's inclusion of relationships, hierarchies, and synonyms among the various terms" (para. 5). This proactive approach to EHR data cleaning helps researchers move almost seamlessly from problem identification to data analysis.

Shickel et al. (2018) conducted a review of the literature to describe **deep learning** techniques (a specialized form of machine learning) used for the analysis of EHR data. They suggested that deep learning techniques yielded improved predictive models but cautioned that the resultant models were difficult to interpret. "Since correct clinical decision-making can be the difference between life and death, many practitioners must be able to understand and trust the predictions and recommendations made by deep learning systems" (p. 1603). They predict that these deep learning models will improve as research progresses.

It is clear that nurses have only begun to imagine how EHR data mining can inform healthcare practices and support quality improvement.

Ethics of Data Mining

Data mining in health care is dependent on the use of private health information (PHI). Practitioners engaging in data mining must ensure that such data are de-identified and that confidentiality is maintained. Because most data mining depends on the aggregation of data, maintaining individual patient confidentiality should be relatively straightforward. Changes and specific requirements for compliance with the Health Insurance Portability and Accountability Act (HIPAA) can be followed at this website: www.hhs.gov/hipaa/for-professionals/special-topics/research/index.html.

A relatively new ethical issue has surfaced related to **digital phenotyping**, which is the use of individual data collected by wearable technologies to identify health issues and, more commonly, mental health status. As Martinez-Martin et al. (2018) described, "The novel ethical challenges posed by digital phenotyping arise from the way that the technology can transform seemingly mundane data into powerful indicators of mental function, with implications not only for healthcare but potentially in a range of areas where a measure of a change in cognitive performance or mood might have broad implications" (p. 2). These data are not collected in the healthcare context, and as such they are not subject to HIPAA. However, as Martinez-Martin et al. argued, if these data are to be interpreted as part of the health status, then there needs to be better information provided to the wearers so that they can better control how their data are used. Stay tuned because the informed consent and ethical landscape related to use of personal data is sure to evolve.

Artificial Intelligence, Machine Learning, and Deep Learning

The field of AI deals with the conception, development, and implementation of informatics tools based on intelligent technologies. By using machines, this field attempts to mimic the complex processes of human thought and intelligence. Because of the vast amounts of data generated every day, it was inevitable that health care would enter the AI arena. Although it is not likely that AI and its related components of machine learning and deep learning will replace human thinking and the "art of health care," they will certainly augment healthcare practice. As Jiang et al. (2017) pointed out, "[b]efore AI systems can be deployed in healthcare applications, they need to be 'trained' through data that are generated from clinical activities, such as screening, diagnosis, treatment assignment and so on, so that they can learn similar groups of subjects, associations between subject features and outcomes of interest" (p. 230).

Garbade (2018) offered a simple explanation of the differences between AI, machine learning, and deep learning. He provided a diagram of concentric circles (imagine a target) with AI in the outermost ring, machine learning in the middle ring, and deep learning in the central ring. As such, he classified machine learning and deep learning as subsets of AI. If a machine completes a task as a result of a defined set of instructions, also known as an **algorithm**, "such an 'intelligent' behavior is what is called artificial intelligence" (para. 13). Machine learning is when machines process large amounts of data and improve their output on the basis of what was learned via the processing. Deep learning utilizes a more sophisticated type of algorithm, known as an artificial neural network. Jiang et al. (2017) further described deep learning processing as the ability to explore a complex neural network with many layers rather than the typical linear processing common in

simple neural networks. This technique is particularly useful for analysis of images because of their complexity. Image analysis AI is commonly used in radiology, particularly for analyzing chest X-rays, diagnosing cataracts and retinopathies, and distinguishing between malignant and benign skin lesions (Jiang et al., 2017).

Daley (2023) provided an overview of AI data processing uses in health care. Following are some of the examples:

- PathAI is developing machine learning technology to assist pathologists in making more accurate diagnoses.
- Buoy Health is an AI-based symptom and cure checker that uses algorithms to diagnose and treat illness.
- Enlitic develops deep learning medical tools to streamline radiology diagnoses.
- Freenome uses AI in screenings, diagnostic tests, and blood work to test for cancer.
- Zebra Medical Vision provides radiologists with an AI-enabled assistant that receives imaging scans and automatically analyzes them for various clinical findings it has studied.
- BioXcel Therapeutics uses AI to identify and develop new medicines in the fields of immuno-oncology and neuroscience.

Managing the COVID-19 pandemic also provided some great examples of the use of AI in health care. Best (2020) described that AI is being used to discover drugs already in use that might interfere with the mechanism of infection in COVID-19, detect the outbreak and predict both the spread of the disease and mortality, differentiate COVID-19 lung lesions from other lung diseases in medical images, and monitor the mental health of those experiencing a lockdown. Rowe (2020a) described a conversational AI system that provides automated answers to frequently asked questions to help field the deluge of calls to healthcare systems related to COVID-19. MIT enhanced the SEIR (i.e., susceptible, exposed, infected, recovered) AI algorithm used to predict disease spread "by training a neural network to capture the number of

infected individuals who are under quarantine, and therefore no longer spreading the infection to others" (Rowe, 2020b, para. 4). A new AI platform is currently being tested to accelerate data processing in the long, tedious process of developing drugs that may be useful as a treatment or even as a vaccine for COVID-19 (Lennon, 2020). It is important to remember that AI processing makes use of large amounts of data that are aggregated to describe, predict, or prescribe healthcare actions.

Bioinformatics, Biomedical Informatics, and Computational Biology

We conclude our exploration of informatics-based research processes by introducing three additional terms that you are likely to encounter as data mining evolves. The use of supercomputing techniques in each of these related fields is leading to ever-increasing understanding of biological processes. When we are able to glean insights from these complex analyses, we are able to apply these insights to health care and begin to realize positive outcomes. Bioinformatics can be viewed as a biological or a computer science. Public Health Degrees (n.d.) defined **bioinformatics** as the "application of computer technology and three-dimensional modeling to large sets of biological data" (para. 8).

According to the website of the University of Texas at El Paso (2020), "Bioinformatics is an interdisciplinary science with a focus on data management and interpretation for complex biological phenomena that are analyzed and visualized using mathematical modeling and numerical methodologies with predictive algorithms" (para. 1).

Biomedicine applies information derived from bioinformatics to promote health. According to the website of the Ohio State University College of Medicine (n.d.), "Biomedical Informatics is an interdisciplinary field concerned with unlocking the potential of data and information to solve problems, ultimately improving individual health, health care, public health, and biomedical research" (para. 1).

The Vanderbilt University (n.d.) website suggested that

> *Biomedical Informatics is the interdisciplinary science of acquiring, structuring, analyzing and providing access to biomedical data, information and knowledge. As an academic discipline, biomedical informatics is grounded in the principles of computer science, information science, cognitive science, social science, and engineering, as well as the clinical and basic biological sciences.* (para. 6)

Oregon Health and Science University (n.d.) defined **biomedical informatics** as "the field that is concerned with the optimal use of information, often aided by the use of technology, to improve individual health, health care, public health, and biomedical research" (para. 1). Biomedical informatics is a growing field, with significant applications and implications throughout the biomedical and clinical worlds. These authors believe that biomedical informatics is the application of bioinformatics to health care. Based on these definitions, one gets a flavor for what bioinformatics entails. It is clear that the definition of bioinformatics varies and that there is no single definition that everyone agrees with at the present time.

Computational biology is the activity of analyzing, synthesizing, and interpreting biological data to develop processes, algorithms, or models in order to comprehend and appreciate biological systems and their interrelationships. Computational biology focuses on "theoretical models, computational simulations, and mathematical models for statistical inference" (Carleton, 2021, para. 4). As Carleton further clarifies, "Scientists choosing to study significantly larger data sets or those that require multiple-server networks should instead turn to bioinformatics, which offers resources better suited to organizing and understanding big data" (para. 10).

Summary

Big data is everywhere—data are collected and stored every second of every day. The data in big clinical data sets can get lost, however, which diminishes their value. Therefore, in health care, it is imperative that KDD and AI be used to analyze these data sets to discover meaningful information that will influence healthcare practice. The existing data repositories are ripe for the picking; they contain hidden patterns, trends, and undiscovered nuggets that must be mined to continue to hone healthcare professionals' understanding and improve health care.

Data management is essential so that this process can begin with clean and accurate data. The decisions that are made when conducting the analysis and developing the model and algorithms enable healthcare professionals to predict and discover patterns and trends in the data, thereby making them meaningful. Meaningful information and knowledge must not only be able to be extracted but also shared and disseminated about what is being learned and the new knowledge being generated.

THOUGHT-PROVOKING QUESTIONS

1. Reflect on these terms: *database*, *data warehouse*, and *data mining*. What do they have in common? How do they differ?
2. Describe an issue associated with healthcare data that impedes the construction of meaningful databases and inhibits the data mining process. Which strategies would you use to remedy this situation? Thoroughly describe one strategy and its potential outcomes.
3. Suggest a data mining project for your practice. Which information would you like to have about your practice area that could be extracted using data mining strategies?

4. Data mining is associated with numerous techniques and algorithms. How can you make sure that you select and develop those that best fit your data?

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CHAPTER 23

Generating and Translating Evidence for Practice

OBJECTIVES

1. Clarify the differences between evidence-based practice and translational research.
2. Explore the potential contributions of bioinformatics and computational biology to evidence for practice.
3. Explore models for introducing research findings into practice.
4. Assess barriers to research utilization in practice.

KEY TERMS

- Agency for Healthcare Research and Quality (AHRQ)
- clinical informatics
- clinical research informatics
- context of care
- evidence
- evidence-based practice (EBP)
- implementation science
- Iowa model
- meta-analysis
- Open Access Initiative
- qualitative study
- quantitative study
- randomized controlled trial (RCT)

- research utilization
- research validity
- translational bioinformatics
- translational informatics
- translational research

Introduction

Mr. James is an 87-year-old man with osteoarthritis in his knees. He is frail and very thin and requires assistance getting out of bed. Mary, a new registered nurse, is making her rounds with her team members and nurse's aide. Realizing Mr. James is at risk for skin breakdown and falls, she reviews the agency policy manual regarding pressure ulcer and fall prevention. Which other resources could Mary consult if she wanted more information on preventing these issues? If Mary wanted to know what the current research suggests about preventing each of these conditions, how would she obtain this information?

This chapter introduces the concept of translational research and its role in evidence-based practice (EBP) with a specific emphasis on nursing informatics and bioinformatics. Before pursuing the content in this chapter, the reader should already understand nursing research, the Foundation of Knowledge model, and knowledge generation through nursing research. Next, key words and definitions used in this chapter are briefly described. Classic sources (5 years or older) are used to enhance the reference base and give the reader a sense of the evolution of translational science and EBP.

Clarification of Terms

Evidence-based practice, *translational research*, and *research utilization* are terms that have been used to describe the application of evidential knowledge to clinical practice. The following paragraphs explore the definitions of each term. Although these terms are related, they have slightly different meanings and applications.

Evidence-based practice (EBP), developed originally for its application to medicine, was classically defined by Sackett et al. (1996) as "[t]he conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients" (p. 71). The "best evidence" in this context refers to more than just research. Goode and Piedalue (1999) stated that EBP should be combined with other knowledge sources and "involves the synthesis of knowledge from research, retrospective or concurrent chart review, quality improvement and risk data, international, national, and local standards, infection control data, pathophysiology, cost effectiveness analysis, benchmarking data, patient preferences, and clinical expertise" (p. 15). EBP starts with a clinical question to resolve a clinical problem (**Figure 23-1**). For example, published research studies are used in healthcare quality initiatives as the evidence behind the development of practice algorithms designed to decrease practice variability, increase patient safety, improve patient outcomes, and eliminate unnecessary costs. Use of EBP promotes the use of clinical judgment and knowledge in relation to the patient's contextual situation and preferences, with procedures and protocols being linked to scientific evidence rather than based on what is customary practice or opinion. Weiss et al. (2018) suggested that "the focus of EBP is the systematic process of review, critique, and synthesis of research evidence and relevant sources of nonresearch evidence to develop a best practice protocol incorporating logistical considerations for implementation in the local context" (p. 427). The relevant sources of nonresearch refer to

organizational values, local data, local context, and patient preferences.



Figure 23-1 Evidence-Based Practice

Research utilization is the use of findings from one or more research studies in a practical application unrelated to the original study (Polit & Beck, 2008, p. 29), resulting in the generation of new knowledge. Stetler (2001) defined research utilization as the

"process of transforming research knowledge into practice" (p. 274). Research utilization can be self-limiting if research is inconsistent or not enough research is available to develop a consensus regarding the answer to the clinical question (Kirchhoff, 2004). Squires et al. (2011) discussed four distinct types of research utilization: overall use; conceptual use, where research prompted a change in thinking but not necessarily practice; symbolic (persuasive) use, where research was used to support a position or influence the position of another; and the direct application of research findings in practice (instrumental use).

Translational research refers to the methods used in translating medical, biomedical, informatics, and nursing research into bedside clinical interventions. As depicted in **Figure 23-2**, new things, new ideas, new techniques, and new approaches must progress through several stages before they are widely implemented in practice. Woolf (2008) described translational research in two ways:

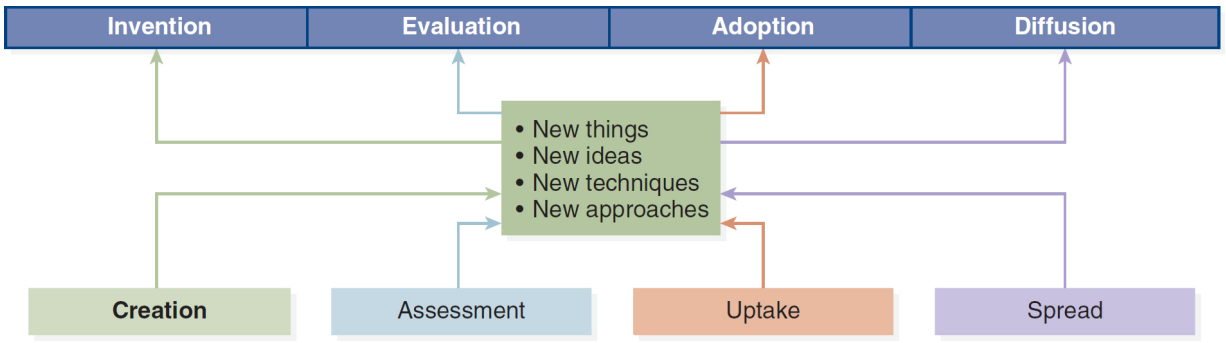


Figure 23-2 Translational Research Pathways

- T1: The transfer of clinical research to its first testing on humans
- T2: The transfer of clinical research to an everyday clinical practice setting

The National Center for Advancing Translational Sciences (NCATS, 2021) developed a translational science spectrum that expands on Woolf's original description of progress toward clinical application. The NCATS spectrum includes basic research, preclinical research, clinical research, clinical implementation, and public health. "At all

stages of the spectrum, NCATS develops new approaches, demonstrates their usefulness and disseminates the findings. Patient involvement is a critical feature of all stages in translation" (para. 1).

Difficulties in translating research to the clinical practice setting exist when research applications do not fit well within the clinical context or when practical considerations constrain the application in a clinical setting. Translational research is complicated by the follow-up analysis, practice, and policy changes that occur when adopting research into practice; consequently, available healthcare EBPs often are not fully incorporated into daily care (Titler, 2004, 2010). As Aarden et al. (2021) pointed out in their examination of the translational lag narrative, "basic science rapidly produces new insights into the biological determinants of human health and disease, but clinical innovation fails to deliver new tools to improve patient care at a comparable pace" (p. 2). Organizational culture influences the changes made to a clinical application and establishes the groundwork and the support for change-making activities (Titler, 2004). The study of ways to promote the adoption of evidence in a healthcare context is called translation science (Titler, 2010). NCATS (2019) of the National Institutes of Health (NIH) provided this definition of translation: "[t]he process of turning observations in the laboratory, clinic and community into interventions that improve the health of individuals and the public—from diagnostics and therapeutics to medical procedures and behavioral changes" (para. 2). Access this center at https://ncats.nih.gov.

Translational bioinformatics is the "development of storage, analytic, and interpretive methods to optimize the transformation of increasingly voluminous biomedical data and genomic data, into proactive, predictive, preventive, and participatory health" (American Medical Informatics Association [AMIA], n.d.-c, para. 1). It integrates biological and clinical data and the evolution of clinical informatics methodology to include biological observations. "The end product of translational bioinformatics is newly found knowledge from these integrative efforts that can be disseminated to a variety of stakeholders, including biomedical scientists, clinicians, and patients" (AMIA, n.d.-c, para. 1).

Clinical informatics is the "application of informatics and information technology to deliver healthcare services. It is also referred to as applied clinical informatics and operational informatics" (AMIA, n.d.-a, para. 1).

Clinical research informatics is defined by AMIA (n.d.-b) as involving the use of informatics in the discovery and management of new knowledge relating to health and disease. "It includes management of information related to clinical trials and also involves informatics related to secondary research use of clinical data. Clinical research informatics and translational bioinformatics are the primary domains related to informatics activities to support translational research" (para. 1).

History of Evidence-Based Practice

Research results are crucial to furthering EBP. The concept of using **randomized controlled trials (RCTs)** and systematic reviews as the gold standard against which one should evaluate the validity and effectiveness of a clinical intervention was introduced in 1972 by Archie Cochrane (1972), a scientist and physician. Cochrane's experiences as a prisoner of war and medical officer while interning during World War II led to his belief that not all medical interventions were needed and that some caused more harm than good. Cochrane viewed the RCT as a means of validating clinical interventions and limiting the interventions to those that were scientifically based, effective, and necessary (Dickersin & Manheimer, 1998). As explanatory information, an RCT involves testing an intervention in a study with two randomly selected groups, one receiving the intervention and the other serving as a control group. A systematic review is a collection and analysis of research on a particular topic (more on this later).

Cochrane's colleague, Iain Chalmers, began compiling a comprehensive clinical trials registry of 3,500 clinical trial results in the field of perinatal medicine. In 1988, after being published in print 3 years earlier, the registry became available electronically. Chalmers's methods for compiling the trials database became a model for future registry assembly. Eventually, the National Health Service in the United Kingdom, recognizing the value of and need for systemic reviews for all of health care, developed the Cochrane Center. The Cochrane Collaboration was initiated in 1993 and expanded internationally to maintain systematic reviews in all areas of health care (Dickersin & Manheimer, 1998). Many universities subscribe to the Cochrane Collaboration database, making this information easily accessible to students, faculty, and nurses who work for university hospital systems. Visit www.cochrane.org for the latest Cochrane evidence. Cochrane announced in 2019 its intention

to establish a new Cochrane network across the United States. Access the U.S. network here: http://US.cochrane.org

Evidence

The RCT is considered the most reliable source of **evidence**. Yet RCTs are not always available; consequently, nurses must use critical analysis using the best available evidence on which to base their clinical decision-making (Baumann, 2010). The updated Stetler (2001) model of research utilization identified internal and external forms of evidence. External evidence originates from research and national experts, whereas internal forms of evidence originate from nontraditional sources, such as clinical experience and quality improvement data.

Evidence includes standards of practice, codes of ethics, philosophies of nursing, autobiographical stories, esthetic criticism, works of art, **qualitative studies**, and patient and clinical knowledge (Melnyk et al., 2000). French (2002) summarized evidence as "truth, knowledge (including tacit, expert opinion and experiential), primary research findings, meta-analyses and systematic reviews" (p. 254). Brown (2013) provided this definition of evidence: "Objective knowledge or information used as the basis for a clinical protocol, clinical decision, or clinical action. Evidence sources include research, agency data regarding system performance and patient outcomes, large healthcare databases, and expert opinion" (p. 439). Nurses may additionally draw on evidence from the **context of care**, such as audit and performance data, the culture of the organization, social and professional networks, discussion with stakeholders, and local or national policy (Rycroft-Malone et al., 2004, p. 86).

Concern has been voiced by nurse theorists that nurses are being influenced too much by the medical model in accepting the RCT as the only true source of evidence, thereby "reverting to the medical perspective" rather than incorporating "theory-guided evidence and diverse ways of knowing" (Fawcett et al., 2001, p. 115). The context change from medicine to nursing requires nurses to apply other knowledge and nursing theory. The use of research results as the

sole basis for clinical decision-making ignores other types of evidence inherent in nursing practice (Scott-Findlay & Pollock, 2004).

To use evidence in practice, the weight of the research, also called **research validity**, must be determined. Evidence hierarchies have been defined to grade and assign value to the information source. For example, a classic evidential hierarchy developed by Stetler et al. (1998) prioritized evidence into six categories:

1. Meta-analysis
2. Individual experimental studies
3. Quasi-experimental studies
4. Nonexperimental studies
5. Program evaluations, such as quality improvement projects
6. Opinions of experts

The hierarchy identifies meta-analysis as the highest-quality evidence because it uses multiple individual research studies to reach a consensus. It is interesting to note that opinions of experts are considered the least significant in this hierarchy, yet nurses most often seek the opinion of a more experienced colleague or peer when searching for information regarding patient care (Pravikoff et al., 2005).

Qualitative research allows one to understand the way in which the intervention is experienced by the researcher and the participant and the value of the interventions to both parties (O'Neill et al., 2007). Qualitative research is not always considered in EBP because methods for synthesizing the evidence are more difficult to accomplish and interpret. The Cochrane Qualitative Research Methods Group has developed search, appraisal, and synthesis methodologies for qualitative research (Joanna Briggs Institute, n.d.) and provides a database of articles related to methodological research (Cochrane Methods, n.d.).

Bridging the Gap Between Research and Practice

The time between research dissemination and clinical translation may be significant, and this delay may adversely affect patient outcomes. Bridging the gap between research and practice requires an understanding of the key concepts and barriers, access to research findings, access to clinical mentors for research understanding, a reinforcing culture, and a desire on the part of the clinician to implement best practices (Melnyk, 2005; Melnyk et al., 2005). In the **Iowa model** of EBP, research and other evidential sources are adopted directly in the practice setting with the goal of developing a standard of care and team decision-making (Schaffer et al., 2013; Titler, 2007). In addition, the groundwork required to create a conceptual framework supportive of an EBP includes workplace culture change and support of the change through leadership (Stetler et al., 1998). Beliefs and attitudes, involvement in research activities, information seeking, professional characteristics, education, and other socioeconomic factors are potential determinants of research utilization (Estabrooks et al., 2003); however, meta-analysis points out that too much original research and not enough repetition of previous studies fails to advance the knowledge base.

Developing countries are often constrained economically from accessing research sources. Organizations, such as the Cochrane Collaboration, provide free reviews to fill this void. Even so, knowledge dissemination strategies and education are required to take advantage of these resources.

In the past decade, two new research approaches have emerged that hold promise for bridging the gap between research and practice: action research and **implementation science**. Unlike traditional research, where the goal is to contribute to the body of nursing knowledge, these two approaches focus on studying the

process of evidence as it is implemented in the clinical setting. Think of a quality improvement project with data collection and the goal of knowledge dissemination after implementation.

The National Cancer Institute sponsors an online self-paced training program titled Training Institute for Dissemination and Implementation Research in Cancer. Access it at https://cancercontrol.cancer.gov/IS/training-education/tidirc/openaccess.html. The University of Washington also sponsors the Implementation Science Resource Hub. Access it at https://impsciuw.org.

Barriers to and Facilitators of Evidence-Based Practice

Tacia et al. (2015) concluded that there are six challenges or barriers to the application of EBP: "institutional and/or cultural barriers, lack of knowledge, lack of motivation, time management, physician and patient factors, and limited access to up to date, user-friendly technology and computer systems" (p. 93). Nurses may also see the job of interpreting research as too complex or the organizational culture as a barrier to implementation of EBP (Kieft et al., 2014; McCaughan et al., 2002). Many believe that inpatient direct care nurses lack basic knowledge of EBP and must have access to and assistance with technical resources.

Yet Melnyk et al. (2009) noted that a number of factors also facilitate the use of EBP. These driving forces include knowledge and skills in EBP; having a conviction that there is a value to using evidence in practices; and practicing in a supportive culture with tools available to sustain evidence-based care, including access to computers and databases, evidence-based content at the point of care, and the presence of EBP mentors. Tacia et al. (2015) noted that interprofessional collaboration, mentorship, and administrative support were necessary for the adoption of EBP. It is imperative that we remove the barriers and support nurses using EBP as well as continue to mentor and work with those who are just beginning to initiate EBP into their practice.

In a discussion of best practices related to the implementation of the American Association of Critical-Care Nurses' practice alert on hemodynamic monitoring, Von Rueden (2020) identified strategies for practice improvement, including a formal practice gap analysis, education using simulation, nursing rounds, and journal clubs. Interestingly, this discussion centered on a practice alert initiated in 2004 and revised in 2009 and 2016. We must find ways to be more efficient in getting research results into practice.

The Role of Informatics

Computers are used in all areas of research: (1) literature search databases, such as CINAHL; (2) online literature reference lists, such as RefWorks; (3) data capture, collection, and coding; (4) data analysis; (5) data modeling; (6) meta-analysis; (7) qualitative analysis; and (8) dissemination of results (Saba & McCormick, 2006). The context for nursing informatics has expanded to support dramatic changes in the way science is accomplished. Information need and the collaborative component of interdisciplinary research rely heavily on technology and informatics. Technologies, such as social networking, have also improved collaboration. The use of technology and informatics in facilitating interdisciplinary and translational research is a key architectural component of the NIH's (n.d.) reengineering of the clinical research enterprise as part of its road map initiative for medical research. As technology continues to advance, so do the informatics tools available to researchers. The Institute of Translational Health Sciences (n.d.) at the University of Washington is one among many university-based research groups (at this writing in May 2020, 4,175 institutions in 147 countries) that link to REDCap (n.d.), described here:

> *REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources.* (para. 2)

This database is fully compliant with HIPAA (Health Insurance Portability and Accountability Act) and institutional review boards and supports the seamless design of online questionnaires.

Another initiative designed to support translational research and the fast-tracking of research findings into clinical practice is the National Center for Data to Health (CD2H, n.d.), part of NCATS. "By

increasing collaboration, the CD2H fosters a robust translational science informatics ecosystem that collectively develops solutions to solve clinical problems faster, more efficiently, and more effectively" (CD2H, n.d., para. 2). This center has also recently added the National COVID Cohort Collaborative (N3C) in response to the pandemic.

Clinical research informatics at the Oregon Clinical and Translational Research Institute (n.d.) accelerates translational research "by providing a full suite of informatics tools for bench-to-bedside, clinical and health care systems research. Program activities span the translational spectrum, from Translational Bioinformatics to Clinical Research Informatics" (para. 1). Many other universities are utilizing informatics tools, software, and databases to engage in translational research. **Translational informatics** refers to the application of research informatics to translational research in order to close the gap from research to the bedside to improve the health of patients and the community.

An informatics infrastructure is critical to EBP. As early as 2008, Bakken et al. discussed expanding the context of informatics to genomic health care, shifting research paradigms, and social web technologies. Ensuring the global collaborative nature of nursing research for 2010 through 2018 required an expansion of the nursing research agenda to user information needs, data management, information support for nurses and patients, practice-based knowledge generation, and design evaluation methodologies. Giuse et al. (2005) described the evolving role of the clinical informationist (i.e., informaticist) as being a partner on the healthcare team who provides timely clinical evidence for the clinical workflow. Although not specific to nursing informatics, NCATS (2023) provides awards under its Clinical and Translational Science Awards (CTSA) program to accelerate the transfer of research to the clinical setting. The Quality and Safety Education for Nurses (QSEN, 2022) cites key competencies (i.e., knowledge, skills, and attitudes) in both EBP and informatics. With the goal of promoting the use of research findings and tool use based on these findings, the **Agency for Healthcare Research and Quality (AHRQ)** became an active

participant in pushing evidence forward into practice. The AHRQ is a government-sponsored organization with the mission of reducing patients' risk of harm, decreasing healthcare costs, and improving patient outcomes through the promotion of research and technology applications focused on EBP. In 1999, AHRQ (2022) implemented its Translating Research into Practice (TRIP) initiative to generate knowledge about evidence-based care. In the second TRIP (TRIP-II) initiative, the focus shifted to improving health care for underserved populations and using information technology to shape translational research and health policy.

A growing number of printed and electronic resources are available to assist in creating guidelines and offering information about EBP. A selection of existing websites is shown in **Table 23-1**.

TABLE 23-1 The Role of Informatics: Online Evidence-Based Resources

Website	Description
Agency for Healthcare Research and Quality www.ahrq.gov	The Agency for Healthcare Research and Quality contains a wealth of information regarding healthcare quality. There is no charge for access to the site or its resources.
BMJ Best Practice bestpractice.bmj.com/info/us	BMJ Best Practice takes you quickly and accurately to the latest evidence-

Website	Description
	based information, whenever and wherever you need it. Its step-by-step guidance on diagnosis, prognosis, treatment, and prevention is updated daily using robust evidence-based methodology and expert opinion.
Orelena Hawks Puckett Institute www.puckett.org	The Orelena Hawks Puckett Institute is a not-for-profit organization engaging in activities that enhance and promote healthy child, parent, and family functioning. Its goal is to foster adoption of EBPs that build on the capacities and strengths of children, parents, families, communities, and public and

Website	Description
	private organizations.
The Centre for Evidence-Based Medicine www.cebm.net	The Centre for Evidence-Based Medicine, located in Oxford in the United Kingdom, is devoted to developing and promoting evidence-based resources for healthcare professionals. In addition to free articles, the site also provides free teaching resources and presentations.
CINAHL Complete www.ebsco.com/products/research-databases/cinahl-complete	CINAHL information system offers a multitude of online services, which include website link sources, CINAHL's online nursing and allied health database, document delivery, and search services.

Website	Description
Cochrane www.cochrane.org	Cochrane's mission is to promote evidence-informed health decision-making by producing high-quality, relevant, accessible systematic reviews and other synthesized research evidence. Its work is internationally recognized as the benchmark for high-quality information about the effectiveness of health care.
PubMed https://pubmed.ncbi.nlm.nih.gov	PubMed comprises more than 30 million citations for biomedical literature from MEDLINE, life science journals, and online books. Citations may include links to full-text content from PubMed Central

Website	Description
	and publishers' websites.
Joanna Briggs Institute https://jbi.global	The Joanna Briggs Institute was established in 1996 as a resource for best care practices. Joanna Briggs was the first matron of the Adelaide Hospital in Australia and is recognized for her financial and organizational support. The Joanna Briggs Institute is a leader in developing EBPs.
The Johns Hopkins University Evidence-Based Practice Center www.jhsph.edu/research/centers-and-institutes/johns-hopkins-evidence-based-practice-center	The Johns Hopkins University Evidence-Based Practice Center was established in 1997 and is one of 14 such centers producing comprehensive, systematic reviews for the AHRQ.
PubMed Central www.ncbi.nlm.nih.gov/pmc	PubMed Central is a free digital

Website	Description
	archive of science-related articles managed by the National Center for Biotechnology Information. BioMed Central (an open source online archive) may be accessed here.
Trip Medical Database www.tripdatabase.com	The Trip medical database is a clinical search tool that allows clinicians to identify the best evidence for clinical practice.
Worldviews on Evidence-Based Nursing https://sigmapubs.onlinelibrary.wiley.com/journal/17416787	This magazine, sponsored by Sigma Theta Tau International, is dedicated exclusively to evidence-based nursing articles. The magazine is also offered online by subscription.

Developing Evidence-Based Practice Guidelines

Several models have been developed to guide organizations into translating research into practice. Brief descriptions of these models are provided in **Table 23-2**. As an example, Titler (2007) identified the steps in the Iowa model for translating research into practice as (1) identifying the problem, issue, or topic in nursing practice; (2) research and critique of related evidence; (3) adaptation of the evidence to practice; (4) implementation of the EBP; and (5) evaluation of patient outcomes and care practices. Careful analysis and discussion of the research or other forms of evidence in this scenario may reveal that, given the context, implementation may not be practical. Following implementation, results must be monitored to determine whether the application works for the context. Thoughtful discussion of the findings will help the clinical team determine whether further research or change is warranted. As a practical application, evidence-based standards for care are developed by hospitals to meet the American Nurses Association/American Nurses Credentialing Center standards for achieving Magnet hospital recognition.

TABLE 23-2 Comparison of Model Approaches to Evidence-Based Practice

Stetler Model (2001)	ACE Star Model (Stevens, 2002)	Iowa Model of Evidence-Based Practice to Promote Quality Care (Titler et al., 2001)
1. Preparation 2. Validation	1. Discovery	1. Select the trigger as impetus for practice (knowledge- or practice-focused) change.

3. Cooperative evaluation 4. Decision-making 5. Translational application 6. Evaluation	2. Evidence summary 3. Translation 4. Integration 5. Evaluation	2. Determine whether the topic is worth pursuing for the organization, and if not, pursue a new trigger. 3. Determine whether there is a significant research base. If so, change; otherwise, conduct or seek more research. 4. If change is appropriate for practice, implement change. 5. Monitor results. 6. Disseminate results.

Information technology is important in synthesizing the research regardless of the model. Bakken (2001) recommended (1) standardized nomenclature required for the electronic health record (standardized terminologies and structures); (2) digital sources of evidence; (3) standards that facilitate healthcare data exchange among heterogeneous systems; (4) informatics processes that support the acquisition and application of evidence to a specific clinical situation; and (5) informatics competencies (p. 1999). Bakken's recommendations encouraged the development of an infrastructure that creates a database of experiential clinical evidence.

Meta-Analysis and Generation of Knowledge

Systematic reviews combine results from multiple primary investigations to obtain consensus on a specific area of research. Studies are discarded from the review if they are not considered sound, thereby creating a reliable end result. The strength of the systematic review is its ability to corroborate findings and reach consensus. Systematic reviews show the need for more research by revealing the areas where quantitative results may be lacking or minimal. Bias may occur if the selected studies are inadequate, all sources of evidence are not investigated, or the publications selected are not adequately diverse (Lipp, 2005). The BMJ Clinical Evidence Blog (https://blogs.bmj.com) has stressed the importance of getting evidence into health service decision-making and being cautious of evidence spin that adds bias to the reporting of the evidence.

Meta-analysis, a form of systematic review, uses statistical methods to combine the results of several studies (Cook et al., 1997). **Quantitative studies** are typically used. According to Glass (1976), "[M]eta-analysis is the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings" (p. 3).

A typical documentation search strategy for meta-analysis begins with the identification of studies through a search of bibliographic databases, identification of meta-analysis articles that match the search criteria, elimination of those articles that do not match the search criteria, review of the reference lists in the meta-analysis for other articles that may relate to the topic, and a review of each article for quality and content. Additional sources should include unpublished works, such as conferences and dissertation abstracts, with the goal of obtaining as many relevant articles as possible. Gregson et al. (2002) identified the steps of a meta-analysis as (1) defining the problem, followed by protocol generation; (2) establishing study eligibility criteria, followed by a literature search; (3) identifying the heterogeneity of results of studies; (4)

standardizing the data and statistically combining the results; and (5) conducting sensitivity testing to determine whether the combined results are the same. The often-cited criticism of meta-analysis is that the emphasis is on quantitative studies, not qualitative studies. In addition, the analysis is only as good as the studies used (Gregson et al., 2002). Collection and dissemination of these meta-analyses and systematic reviews are available in paper and on the internet, although many such databases require a subscription.

The term *open access* refers to a worldwide movement to make a library of knowledge available to anyone with internet access. The **Open Access Initiative** came about in response to the tremendous cost of research library access. Libraries pay large fees for journal subscriptions, and the richness of library references is limited to what the budget allows. The cost of keeping current with research has caused library subscriptions to decline (Yiotis, 2005). Open access adds to the controversy, with some journals charging authors for publication of their work, which in itself may provide a financial barrier to publication in this form.

According to Suber's (2004) open access overview, open access refers to digital literature that is available to anyone with internet access free of charge. There are two vehicles for open access: archives and journals. Open access journals are generally peer reviewed and freely available. The publishers of open access journals do not charge the reader but rather obtain funds for publishing elsewhere. Open access journals may charge the author or depend on other forms of funding, such as donations, grants, and advertising, to publish. SPARC (Scholarly Publishing and Academic Resources Coalition, n.d.) pointed out that most research is funded by government agencies and conducted in academic research centers; however, "[o]nce published, those that contributed to the research (from taxpayers to the institutions that supported the research itself) have to pay again to access the findings. Though research is produced as a public good, it isn't available to the public who paid for it" (para. 3). Open access promotes research collaboration and fast-tracking of results into practice.

Expanding Research Boundaries and Effects on Clinical Translation

Thus far in this chapter, we have been focused on more traditional research methods and concepts. However, the fields of biomedical informatics and computational biology are making important contributions to our understanding of the basis of disease and allowing us to examine huge data sets searching for important insights. When the human genome project was instituted, there was a great deal of excitement in the scientific community because of the potential for understanding human biological processes and diseases. As with all research, there is still a considerable time lag before clinical change.

The future of health care is based on genomics. Bioinformatics and computational biology have provided the tools to make it possible to analyze and interpret complex biological processes. Through these developments, several projects have advanced understanding of the human genome, haplotypes, and the genomic changes related to disease. The complete sequencing of the human genome has led to the systems biology referred to as omics and has elevated scientists' ability from studying one gene or protein to studying fundamental biological processes (**Box 23-1**).

BOX 23-1 *OMICS*

Ome and *omics* are suffixes derived from the term *genome*. National Public Radio (2010) credits botanist Hans Winkler with merging "the Greek words 'genesis' and 'soma' to describe a body of genes" (para. 1) in 1920. The term *genome* was born from this combination, and *genomics* arose as the study of the genome.

Scientists describe a large-scale system or complex using the *ome* suffix to form words such as

- proteome, a collection of proteins in a cell or tissue;
- metabolome, a collection of metabolites; or

- transcriptome, a collection of RNA that has been transcribed from genes.

High-throughput analysis is critical when dealing with a large subset of data at the *omic* level: DNA sequences, gene expression levels, or proteins.

The goal of the International HapMap Project (National Human Genome Research Institute [NHGRI], 2012) was to

> *develop a haplotype map of the human genome, the HapMap, which will describe the common patterns of human DNA sequence variation. The HapMap is expected to be a key resource for researchers to use to find genes affecting health, disease, and responses to drugs and environmental factors. The information produced by the Project will be made freely available.* (para. 1)

This international partnership of scientists has taken blood samples from clusters of related people, such as parents and children, from different international regions. Using these samples, the researchers have been able to catalog some of the common variations in DNA and investigate inherited alleles. As the name implies, a haplotype map identifies a set of closely linked alleles on a chromosome, which tend to be inherited together (**Figure 23-3**).

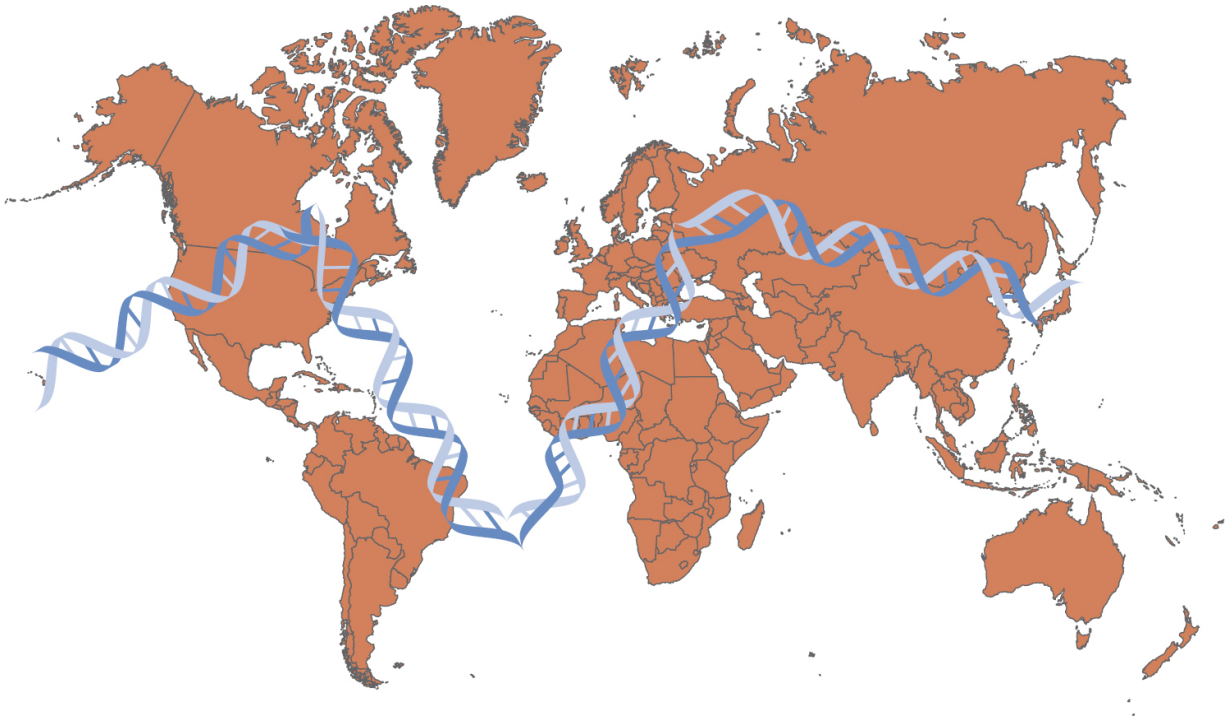


Figure 23-3 International HapMap Project

Modified from: National Human Genome Research Institute. (2012). *International HapMap Project.* www.genome.gov/10001688/international-hapmap-project.

The International HapMap Project states that

> *[m]ost common diseases, such as diabetes, cancer, stroke, heart disease, depression, and asthma, are affected by many genes and environmental factors. Although any two unrelated people are the same at about 99.9% of their DNA sequences, the remaining 0.1% is important because it contains the genetic variants that influence how people differ in their risk of disease or their response to drugs. Discovering the DNA sequence variants that contribute to common disease risk offers one of the best opportunities for understanding the complex causes of disease in humans.* (para. 3)

In 2006, the Cancer Genome Atlas Program (National Cancer Institute, n.d.) began. This pilot project cost $100 million to map the genomic changes in brain, lung, and ovarian cancers to assess the feasibility of a full-scale effort to systematically explore the entire spectrum of genomic changes involved in every major type of human cancer. The goal of this project was to develop a resource that will be used to develop new strategies for preventing, diagnosing, and treating the disease.

A major contribution has been the Human Genome Project (HGP, 2019), which began in 1990 and was completed in 2003. The U.S. Department of Energy and the NIH coordinated this program, which had the following goals:

- Identify all of the approximately 20,000–25,000 genes in human DNA
- Determine the sequences of the 3 billion chemical base pairs that make up human DNA
- Store this information in databases
- Improve tools for data analysis
- Transfer related technologies to the private sector
- Address the ethical, legal, and social issues (ELSI) that may arise from the project (para. 2)

According to NHGRI (2015), "One of the most important aspects of bioinformatics is identifying genes within a long DNA sequence" (para. 1). It was clear that the speed of DNA sequencing would have to be realized sooner to decrease costs. The process was refined so that the sequencing was improved. It took 4 years to sequence the first billion bases but just 4 months to sequence the second billion bases.

During the month of January 2003, 1.5 billion bases were sequenced. As the speed of DNA sequencing increased, the cost decreased from $10 per base in 1990 to $0.10 per base at the conclusion of the project in April 2003 (NHGRI, 2015).

One of the most important aspects of bioinformatics is identifying genes within a long DNA sequence. Until the development of bioinformatics, the only way to locate genes along the chromosome was to study their function in the organism (in vivo) or to isolate the DNA and study it in a test tube (in vitro). Bioinformatics allows scientists to make educated guesses about where genes are located simply by analyzing sequence data using a computer (in silico) (NHGRI, 2015).

The other major concern brought out through the HGP was the realization that ethical, social, and legal implications (ESLI) arise from studying human genomes. The participants in the HGP set aside a percentage of their annual budgets to research ESLI (HGP, 2008). **Box 23-2** and **Figure 23-4** identify some of the questions raised regarding ESLI. In 1990, the NIH created a specific research program targeting ESLI and addressing human diversity, including communities and healthcare needs that may not have not been fairly considered. In 2022, the 5th Annual ESLI Congress was titled "Innovating for a Just and Equitable Future" (NHGRI, 2023).

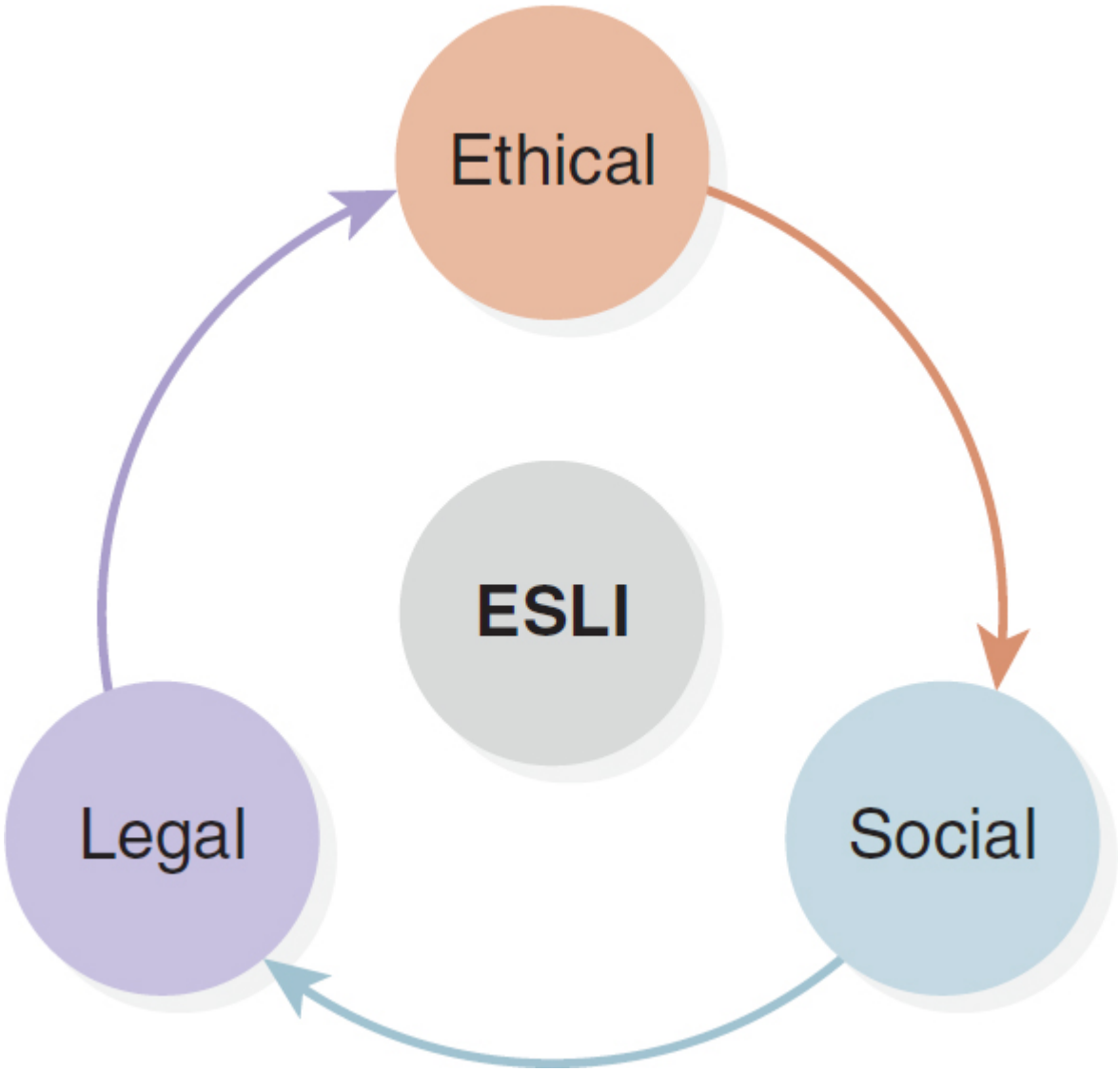


Figure 23-4 Ethical, Social, and Legal Implications (ESLI)

BOX 23-2 ESLI QUESTIONS RAISED BY THE HUMAN GENOME PROJECT

- Who should have access to personal genetic information, and how will it be used?
- Who owns and controls genetic information?
- How does personal genetic information affect an individual and society's perceptions of that individual?
- How does genomic information affect members of minority communities?

- Do healthcare personnel properly counsel parents about the risks and limitations of genetic technology?
- How reliable and useful is fetal genetic testing?
- What are the larger societal issues raised by new reproductive technologies?
- How will genetic tests be evaluated and regulated for accuracy, reliability, and utility? (Currently, there is little regulation at the federal level.)
- How do we prepare healthcare professionals for the new genetics?
- How do we prepare the public to make informed choices?
- How do we as a society balance current scientific limitations and social risk with long-term benefits?
- Should testing be performed when no treatment is available?
- Should parents have the right to have their minor children tested for adult-onset diseases?
- Are genetic tests reliable and interpretable by the medical community?
- Do people's genes make them behave in a particular way?
- Can people always control their behavior?
- What is considered acceptable diversity?
- Where is the line between medical treatment and enhancement?
- Are genetically modified foods and other products safe for humans and the environment?
- How will these technologies affect developing nations' dependence on the West?
- Who owns genes and other pieces of DNA?
- Will patenting DNA sequences limit their accessibility and development into useful products?

Data from: Human Genome Project. (2008). *Human Genome Project information archive, 1999–2003: Ethical, legal, and social issues*. www.ornl.gov/sci/techresources/Human_Genome/elsi/elsi.shtml.

Even though the HGP has ended, researchers continue to improve DNA sequencing. Specifically, they continue to advance the bioinformatics and computational biology tools that are used in biomedical informatics. These three projects were pivotal in genomics. The HGP focused on the DNA sequence from a single individual, the HapMap Project focused on variation in the genome and on human populations, and the Cancer Genome Atlas Project is

concerned with how cancer affects the genomes. As a result of these seminal projects and a unique culture of data sharing previously unknown among biological researchers, molecular data and measurement tools are now publicly available. Two examples of publicly available databases are the Gene Expression Omnibus, which is maintained by the National Center for Biotechnology Information at the National Library of Medicine, and Array-Express, which is maintained by the European Bioinformatics Institute (Butte, 2008). As new researchers with both biology and computational expertise emerge, bioinformatics and computational biology projects will contribute new insights into disease mechanisms and therapeutic interventions, including drug repurposing. Drug repurposing means identifying new uses for previously Food and Drug Administration–approved drugs (Tang et al., 2022).

We have seen numerous advances ranging from possible treatments for Parkinson's disease and unprecedented detail of the genetics of type 2 diabetes to the NIH creating an atlas of human malformation syndromes in diverse populations, NIH researchers identifying striking genomic signatures shared by five types of cancer, and NIH scientists discovering the genetic cause of a rare allergy to vibration (NIH, 2016). However, it will take many more years of researching and applying bioinformatics and computational biology before the information in the human genome is understood in detail. Because these applications have the ability to allow one to analyze and interpret complex biological processes, researchers are on the path to understanding the etiology of disease and treatment interventions at the molecular level. Jiang et al. (2022) described the use of big data and AI processing "to facilitate biomedical breakthroughs in cancer through cross-modality integration, cross-cohort aggregation and data reuse" and urged the expansion of cancer data sets "to allow better computational models to drive basic research, cancer diagnostics and the development of new therapies" (p. 636).

Consider a typical day on any clinical unit. The advanced practice nurse who wants to prescribe a drug for a patient begins by reviewing the patient's genetic test results. The advanced practice

nurse knows that this information must be assessed before prescribing so that a drug that will treat the patient's illness successfully without producing harmful side effects can be selected. The patient will receive only the medication that they need and one that is designed to interfere with or enhance the specific molecular processes that are the signature for the patient's particular health challenge. The advances that bioinformatics and biomedical informatics promise will dramatically affect healthcare delivery as it is known. As explained by Rajappa et al. (2004),

> *[u]nderstanding molecular mechanisms leads to better classification of disease and better management. A drop of blood from a hypertensive patient gives gene expression profile by cDNA microarray analysis. It may reveal SNPs [single nucleotide polymorphisms] related to hypertension and others which predispose a patient to diabetes mellitus or myocardial infarction and the clinician can determine which drugs are beneficial and which are harmful. This scenario has a whale of difference from the current "trial and error" method of matching a patient with antihypertensives.* (p. 128)

This vision from 2004 has become a reality, and the scope of treatments and interventions continues to expand. Our expectations and hopes are being met and surpassed.

Nurses can be involved in bioinformatics in many ways, including as nurse researchers, helping to map molecular processes, and as educators and advocates, helping patients and families to understand these complex biological processes. For more information about the roles of nurses in this exciting new field, visit the website of the International Society of Nurses in Genetics (www.isong.org).

The Future

The future depends on a prepared workforce ready to meet the challenges of tomorrow. A prepared workforce will require a focus on informatics, bioinformatics, clinical research, translational research, other research methods, and EBP. In this data-driven healthcare delivery system in which nurses work, they must adopt data standards. Given the vast amounts of data, Bakken et al. (2008) identified areas of focus for nursing informatics in knowledge representation, data management, analysis, and predictive modeling in genomic health care and the need for policies and procedures to protect data acquisition, dissemination, privacy, security, and confidentiality as well as education in these areas. Informatics tools support nursing practice, education of healthcare consumers, and knowledge generation. The technology is available now to incorporate evidence into reference links embedded in electronic clinical care plans. Incorporation of personalized clinical desktops to allow each clinician to have appropriate references (similar to internet ad bot technology) provided to them may be possible. The other challenge includes developing and maintaining interprofessional collaborative environments that truly operate in a cooperative and open manner. Time, research, and technology will tell.

Summary

These are amazing times. Technology has taken us faster and further than we ever thought possible. Healthcare jobs have become more technical and complicated. In some ways, technology has increased the margin for error. Some healthcare practitioners will continue to rely on little scraps of paper and nonsystematic methods to keep themselves and their patients safe. Unfortunately, individuals who become so tied to these things close their mind to new innovations. The evolving quality culture and increased patient safety concerns are dragging healthcare workers forward. For the benefit of patients, health care must move forward.

The discipline of bioinformatics and its use in biomedical informatics epitomize the integration of computer science, information science, computational biology, and health care. These new applications deal with the resources, devices, strategies, and methods needed to optimize the acquisition, processing, storage, retrieval, generation, and use of information in health and biomedicine. Biomedicine and its applications of bioinformatics support and manage all healthcare behaviors. They affect how clinicians deliver health care to the infirm, prevent disease, promote health, conduct research, and provide formal education for entry-level practitioners and continuing education for those who are currently practicing. The field of biomedical informatics, which is bioinformatics capabilities coupled with health care, includes informatics and computational biology algorithms and tools and clinical guidelines. This knowledge can be applied to the areas of nursing, pharmacy, laboratory, dentistry, medicine, and public health. Those living the profession of nursing know that the practice of nursing is intertwined with the management and processing of information, including the new knowledge being generated by biomedical informatics. On the biomedical side of informatics, one must be cognizant of the fact that medical data typically are extracted from personal, confidential, and legally protected medical

records. The protection of human subjects must be paramount, and all ESLI must be addressed.

Biomedical informatics provides knowledge about the effects of DNA disparities among individuals. Being able to study human genomes and biological processing at the molecular level will revolutionize how conditions are diagnosed and care is provided. The study of genomics is helping to prevent disease. If one can better understand an organism's biological processes and genetic coding, one can better prevent or treat medical conditions. Clinical care as it is known will change by becoming genomics based. Collaboration, improved access to online libraries, research tool transparency, a common data language, organizational and informational support, and continued research are a short list of items needed to advance translational research. Repeat studies are needed to provide meaningful meta-analysis and systematic reviews. Technology advancement in the area of incorporating evidence into clinical tools must continue. Removing the barriers to knowledge-seeking behavior and providing access to evidential resources will promote knowledge and, in the end, improve patient outcomes.

THOUGHT-PROVOKING QUESTIONS

1. Twelve-hour shifts are problematic for patients' and nurses' safety, yet hospitals continue to keep the 12-hour shift schedule. In 2004, the Institute of Medicine (2004) published a report that referred to studies as early as 1988 that discussed the negative effects of rotating shifts on intervention accuracy. Workers with 12-hour shifts experienced more fatigue than workers on 8-hour shifts. In another study done in Turkey by Ilhan et al. (2006), factors relating to increased risk for injury were age of 24 years or younger, less than 4 years of nursing experience, working in surgical intensive care units, and working for more than 8 hours. As a clinician reading these studies, what would your next step be?
2. The use of heparin versus saline to maintain the patency of peripheral intravenous catheters has been addressed in research for many years. The American Society of Health System Pharmacists published a position paper in January 2006 advocating its support of the use of 0.9% saline in the maintenance of peripheral catheters in nonpregnant adults. It seems

surprising that this position paper references articles that advocate the use of saline over heparin dating from 1991. What do you believe are some of the barriers that would have caused this delay in implementation?

3. In the era of EBP, healthcare providers must continue to think critically about their actions. What is the science behind their interventions? Healthcare workers must no longer do things one way just because they have always been done that way. Research the problem, use evidence-based resources, critically select electronic and nonelectronic references, consolidate the research findings and combine and compare the conclusions, present the findings, and propose a solution. The nurse will be the first to ask why and may be a key player in making change happen.
4. After reading this chapter, you know that the study of genomics is helping clinicians to understand better the interaction between genes and the environment. This new information and knowledge will continue to help clinicians find ways to improve health and prevent disease. How do you envision patient care will change based on genomics in 10 years, 20 years, or 50 years into the future?
5. Review the ESLI raised by the HGP that are presented in Box 23-2. Prepare a similar list of ESLI questions to apply to the public health databases being developed for health information exchanges. Can you appreciate how these ESLI questions are widely applicable to protecting information gathered from human subjects?

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SECTION VII
Imagining the Future of Nursing Informatics

Chapter 24 The Art of Caring in Technology-Laden Environments

Chapter 25 Our Expanding Realities

You might wonder why we are including a chapter on caring as we discuss the future of nursing informatics. We believe that nurses are taught to care and hone their ability to care for patients as they practice; however, considering technologies that can be disruptive, the art of caring can become compromised or lost. We want to refocus nurses on the art of caring while enhancing the science of nursing using informatics tools.

We challenge you to reflect on what you know and what you are learning and to think of where you are going in relation to your own practice and nursing informatics knowledge. Just as our professional and personal lives overlap at times, so do our social and professional informatics and networking experiences. We cannot assume that what we do or use in our personal lives is appropriate or even useful in our professional practice. This section begins with Chapter 24, *The Art of Caring in Technology-Laden Environments,* which considers the heart of what nurses do—caring.

The section ends with Chapter 25, *Our Expanding Realities and the Metaverse.* In this chapter, you will examine emerging technologies that are evolving our sense of reality that will affect the future of health care, nursing practice, nursing informatics, and patient care. We want you to pause and reflect on nursing in the context of informatics and, of course, reality. To help you consider the disruptive forces affecting our realities, we have provided a glimpse of patient experiences in future health care: Brad, a virtual assistive service robot; big data; three-dimensional printing; care bots; cyborgs; the metaverse; and artificial intelligence. Do these

technologies truly become part of our reality and influence our worldview? As we are informed through the use of nursing informatics and expand our knowledge and technology-infused practice, we affect our reality, the reality of the healthcare industry, and the reality of our patients.

Once you finish reading the final chapter of this text, reconsider the Foundation of Knowledge model (**Figure VII-1**). Reflect on reality and how it relates to the four areas of the model: (1) knowledge acquisition, (2) knowledge processing, (3) knowledge generation, and (4) knowledge dissemination and feedback.

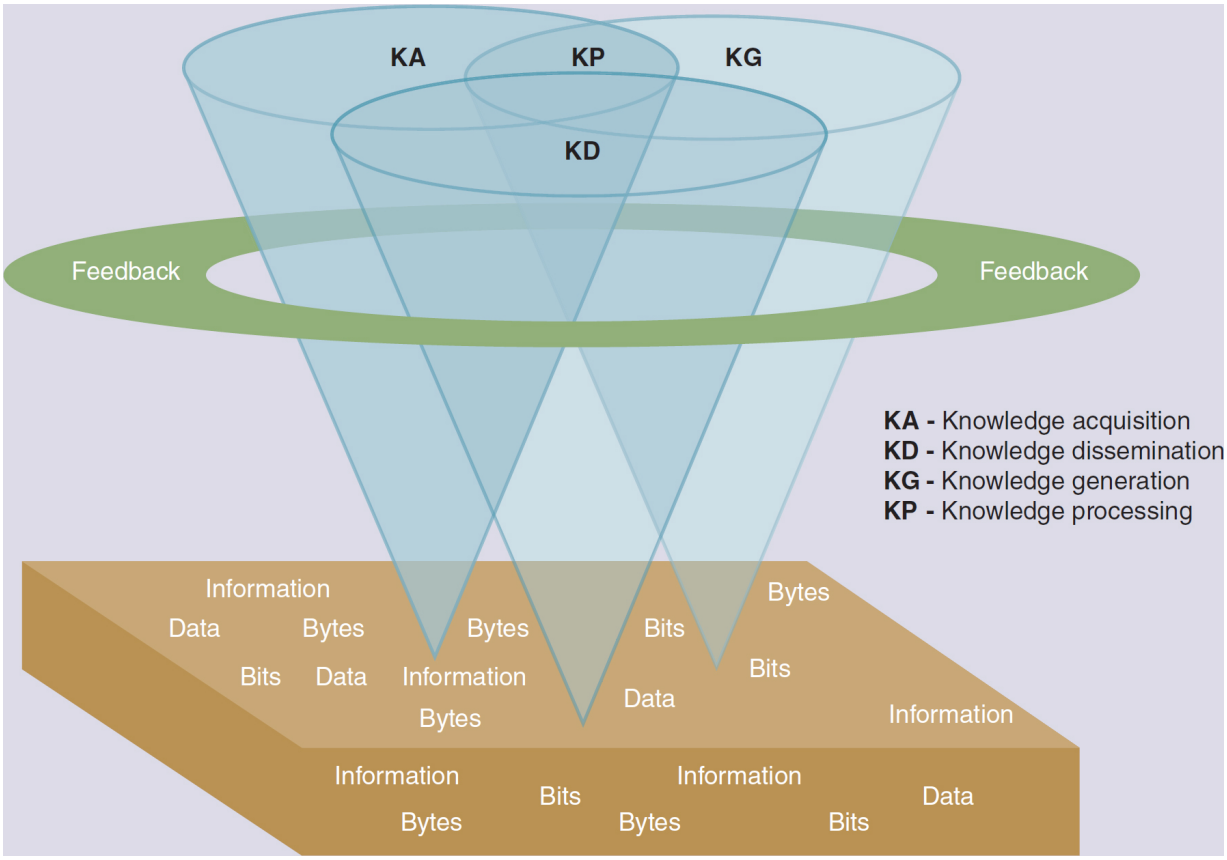


Figure VII-1 Foundation of Knowledge Model

Description

You are challenged to ask, "How can I use my wisdom to help create the nursing realities, the reality of the healthcare industry,

and the reality of our patients in the future?”



CHAPTER 24

The Art of Caring in Technology-Laden Environments

OBJECTIVES

1. Explore caring theories as they apply to the art of nursing.
2. Acknowledge the potential disruption of technology to the therapeutic nurse–patient relationship.
3. Define presence and caring presence.
4. Formulate strategies to enhance caring presence.

KEY TERMS

- active listening
- art of nursing
- caring
- caritas process
- centering
- presence

Introduction

Nursing is hard work. Depending on the site of practice, it can be both physically and mentally taxing. Nurses are masters at multitasking—that is, performing several caring functions simultaneously during a patient encounter. Some nursing interventions are readily apparent and easily described, such as collecting vital signs data and changing dressings, whereas others are less visible yet equally important, such as interpreting the vital signs data, generating knowledge about the patient's situation, and then using that knowledge to inform practice. Equally invisible, yet important to the therapeutic caring environment, are the little things that nurses say, project, and do in the caring episode. In this chapter, we pause to reflect on the art of caring. We emphasize the need to preserve this central and unique function of nursing and suggest ways that nurses can ensure that the caring functions do not become a lost art as technologies are introduced into patient care environments.

We derive a definition of nursing science from the American Nurses Association's definition of nursing. Nursing science is the ethical application of knowledge acquired through education, research, and practice to provide services and interventions to patients to maintain, enhance, or restore their health and to acquire, process, generate, and disseminate nursing knowledge to advance the nursing profession. Caring functions, such as therapeutic communication, listening, touch, and mindfulness, are an integral part of nursing science because they also help patients to maintain, enhance, or restore their health. Although the new technologies, such as smart pumps, barcode medication administration systems, electronic health records (EHRs), wearables, and smartphones, being introduced into our practice environments are designed to increase efficiency, promote safety, and streamline the work of nursing, we need to ask, to what extent do these technologies disrupt the nurse–patient caring encounter? How can we continue to care effectively

for our patients and promote a healing environment while incorporating the advantages and efficiencies that technologies provide? Johnson and Carrington (2023) advocate for adding technology as a fifth dimension of the original nursing metaparadigm (i.e., human, health, nursing, and environment). "To synchronize nursing practice with technology as part of what it means to be a modern-day human is to modernize nursing" (p. 6).

Caring Theories

Much of the work of defining caring and developing caring theories has been done in nursing. The concepts of caring described by nurse theorists are widely applicable to all professional–patient encounters, and nurses can model caring behaviors for other professionals as they provide services and interventions to patients to maintain, enhance, or restore their health.

Anne Boykin and Savina Schoenhofer (2015) defined **caring** as an "altruistic, active expression of love and . . . the intentional and embodied recognition of value and connectedness" (p. 343). In their framework, the theory of nursing as caring, caring is created from each moment nurses are committed to nurturing the patient. Regardless of the challenges presented to nurses, such as technology, time restraints, staffing issues, or difficult patients, they need to reach deeply inside themselves to recognize that knowing the person is caring. Nurses must be able to enter into each nursing situation with the intentional commitment to fully care for the patient.

Caring as a concept is also worth exploring in the seminal work of Jean Watson. Dr. Watson (2015) described the following:

> *The Theory of Human Caring was developed between 1975 and 1979 while I was teaching at the University of Colorado. I tried to make explicit that nursing's values, knowledge, and practices of human caring were geared toward subjective inner healing processes and the life world of the experiencing person. This required unique caring—healing arts and a framework called "carative factors," which complemented conventional medicine but stood in stark contrast to "curative factors."* (p. 322)

It is important to remember that Watson developed her theory during a time when the nursing profession was struggling to define itself and identify the unique contributions of nursing to patient care. In the theory of human caring, Watson defined caring as "healing consciousness and intentionality to care and promote healing" and caring consciousness as "energy within the human–environmental

field of a caring moment" (Watson, 2015, p. 323). Think about the use of the word *energy* in these definitions, and pause to appreciate the level of cognitive energy that nurses expend as they care for patients. Nursing is hard work!

Watson further described the evolution of her theory from the original 10 carative factors to what she now calls **caritas processes**. As her work expanded, she recognized the need for "love and caring to come together for a new form of deep transpersonal caring" (Watson, 2015, p. 324). In the evolving theory, she has emphasized that the "relationship between love and caring connotes inner healing for self and others" (Watson, 2015, p. 324). The 10 caritas processes enumerated by Watson are summarized here:

1. The practice of loving kindness and equanimity within the context of caring consciousness
2. Being authentically present and enabling and sustaining the deep belief system and subjective life world of self and one being cared for
3. Cultivation of one's own spiritual practices and transpersonal self, going beyond ego self, opening to others with sensitivity and compassion
4. Developing and sustaining a helping–trusting, authentic caring relationship
5. Being present to, and supportive of, the expression of positive and negative feelings as a connection with deeper spirit of self and the one being cared for
6. Creative use of self and all ways of knowing as part of the caring process; to engage in artistry of caring–healing practices
7. Engaging in genuine teaching–learning experience that attends to unity of being and meaning, attempting to stay within others' frames of reference
8. Creating a healing environment at all levels (a physical and nonphysical, subtle environment of energy and consciousness,

whereby wholeness, beauty, comfort, dignity, and peace are potentiated)

9. Assisting with basic needs, with an intentional caring consciousness, administering "human care essentials," which potentiate alignment of mind–body–spirit, wholeness, and unity of being in all aspects of care, tending to both embodied spirit and evolving spiritual emergence
10. Opening and attending to spiritual–mysterious and existential dimensions of one's own life–death; soul care for self and the one being cared for (Watson, 2015, p. 325)

The Cycle of Caring described by Skovholt (2005) involves a series of professional attachments and then appropriate separations. Expert professionals are fully present for the person they are attempting to help. The difficulty for professionals is finding a balance between caring enough and caring too much, identified by Skovholt as professional underattachment and overattachment.

Think about a recent patient encounter. Were you fully present in the moment and conscious of the individual and their uniqueness? Did you smile and greet the patient by name and acknowledge visitors? Have you learned how to "smile with your eyes" while wearing a mask? Did you place your tablet (or computer on wheels) to the side, lean forward, adopt an open stance, and attentively listen to the concerns of the patient and family and offer them the opportunity to ask questions? Did you explain what you were doing with and for the patient and why? (See **Figure 24-1**.) Conversely, did you focus your attention on the tablet or computer, hide behind your mask, and talk at the screen as you clicked on the drop-down menus to document the patient encounter? Did the technology and the personal protective equipment create a barrier between you and the patient and their family? Did you depend solely on monitoring technologies to create your interpretation of the patient's experience? Was your assessment of the patient's current situation influenced by the objective representation of the person that the monitoring technologies present in the room created (O'Keefe-McCarthy, 2009)? "The overwhelming presence of technology at the

clinical bedside has the power to become the strongest reference point that nurses use to inform, direct, interpret, evaluate, and understand nursing care" (O'Keefe-McCarthy, 2009, p. 787). We must remember that "[t]echnology, however, does not take into consideration the specific symptom presentation unique to the person experiencing the illness. Technology's use is not meant to replace the person-to-person interaction that is essential in any nurse–patient encounter" (O'Keefe-McCarthy, 2009, p. 792).



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Figure 24-1 Active Listening

Patient-centered care is another way of describing the need for practitioners to focus on the subjective experience of patients with health challenges. Liberati et al. (2015) defined patient centeredness as "a collective achievement that is negotiated between patients and multiple health providers, comprising social practices and

relationships that are woven together through the material and immaterial resources available in specific organizational contexts" (p. 47). They suggested that a focus on patient-centered care may have three outcomes:

- Patients can provide their subjective experience as an input to improve several, often undermined, aspects of healthcare delivery.
- Care providers might develop their capacity for reflexivity, which could improve their understanding of the implications of their actions.
- Patients and practitioners can thus provide insights into the overall health organization on how to innovate processes and facilities to better respond to local needs.

We will examine reflection on practice in more detail later in the chapter.

Central to the caritas processes described by Watson and the discussion about technology-mediated care by O'Keefe-McCarthy is the concept of a caring presence. Strategies for developing and enhancing caring presence are discussed in the latter part of this chapter.

The humanistic nursing theory developed by Paterson and Zderad also offers some insight into the less visible aspects of nursing care (Kleiman, 2010). These authors suggested that the basis of nursing is the response to the call for help in solving health-related concerns.

> *This call, a foundational concept of humanistic nursing, can be heard where nursing is offered, coming to our attention as a subtle murmur of pain, sorrow, anxiety, desperation, joy, laughter, even silence, that expresses the state-of-being of the protagonists in the drama of health-care delivery, our patients and ourselves.* (Kleiman, 2010, p. 338)

Nurses hear the call and respond with their entire being. Their knowledge, experiences, ethics, and competencies shape the interaction with the patient as they respond.

> *In humanistic nursing we say that each person is perceived as existing "all-at-once." In the process of interacting with patients, nurses interweave professional identity, education, intuition, and experiences, with all their other life experiences, creating their own tapestry which unfolds during their responses.* (Kleiman, 2010, pp. 341–342)

Pause to reflect on how you create your own tapestry during patient interactions.

Nursing care requires conscious awareness of self and the uniqueness of each patient. It requires emotional energy expenditure as nurses seek to find ways to meet the calls of their patients. Nurses need to be aware of the potential for inadvertently dehumanizing the patient experience in their technology-laden practice environments. According to Kleiman (2010), "The context of Humanistic Nursing Theory is humans. The basic question it asks of nursing practice is: Is this particular intersubjective–transactional nursing event humanizing or dehumanizing?" (p. 349).

Several recent articles have begun to question the false dichotomy of technology and caring and have suggested that it is possible for technology and caring to coexist in the nurse–patient encounter. Martinez (2019) suggested that human connectedness can be facilitated by technology because technology allows us to know what is unknown about a person. "Technology when aimed at maintaining human connectedness thru the process of knowing then becomes an expression of caring" (p. 13). Locsin (2017) also discussed technological knowing as part of a discussion of the theory of technological competency as caring in nursing. "Knowing persons as a practice process of nursing is revealed in knowledgeable demonstration of intentional, deliberate, and authentic encounters with persons in technologically demanding nursing practice settings, particularly those in environments requiring specialized technological expertise" (p. 162). Finally, Tanioka et al. (2019) discussed the transactive relationship theory of nursing (TRETON) as it relates to the disruptive effects of the introduction of artificial intelligence (AI) into nursing and specifically the use of humanoid nurse robots to perform routine care functions. Several Japanese companies, as well as the universities of Louisville and Texas, are involved in designing

and testing care assistive robots (beyond supply delivery or cleaning robots), which, if they become widely used, will indeed disrupt the typical nurse–patient relationship and precipitate new ways of thinking about the caring process. Review the information about two of these robots at these websites: www.softbankrobotics.com/emea/en/pepper and www.therobotreport.com/rudy-assistive-robot-helps-elderly-age-in-place.

We must be fully present and self-aware in every patient encounter, seeking to deliver exactly what is needed in every situation. Yes, nursing is hard work, but when we are able to respond with our whole being, we may find that our patients and families are more satisfied with the care we provide and we also experience personal satisfaction and find joy in our profession.

Presence

Presence is the act of being there and being with our patients—fully focusing on their needs. "Presence is an interpersonal process that is characterized by sensitivity, holism, intimacy, vulnerability and adaptation to unique circumstances" (Finfgeld-Connett, 2008, p. 528). Paterson and Zderad explained presence as establishing a relationship by being fully available and open to the experiences of another (Penque & Snyder, 2014). Penque and Snyder defined three types of presence: physical presence, full presence, and transcendent presence. A nurse who is physically present is largely competent in carrying out care and efficient with interventions but inattentive to communication and nonverbal cues projected by the patient and family. When fully present, a nurse will greet the patient by name, communicate appropriately with the patient, and pay attention to what is being said and not said during the encounter. When nurses practice transcendent presence, they will first center themselves, clearing their mind of all potential distractions, and then use the patient's name and gentle touch to convey interest and responsiveness while carrying out the necessary physical interventions.

Paterson and Zderad felt that presence was a vital element of their theory of humanistic nursing (Penque & Snyder, 2014). Presence requires nurses to be open and responsive to the situations around them. If they are fully present to the patient in front of them, they will be able to notice the subtle changes that may not be evident if they were present only physically. The connection loss may cause the patient to feel that the nurse is detached from the situation. Penque and Snyder (2014) gave an example of presence from the book *Tuesdays with Morrie* by Mitch Albom:

> *I believe in being fully present. That means you should be with the person you're with. When I'm talking with you now, Mitch, I try to keep focused only on what is going on between us. I am not thinking about something we said last week.*

I am not thinking about what's coming up this Friday. I am not thinking about doing another Koppel show, or about medications I'm taking. I am talking to you; I am thinking about you. (pp. 135–136)

Strategies for Enhancing Caring Presence

Patients have complex problems and needs. They may be scared, angry, resistant to change, or happily oblivious to the extent of their health challenges. Nurses also have complex personal lives with many competing roles and issues that consume their energies. The workplace may be short staffed, resulting in care assignments that stretch them to their maximum. They may be struggling to learn to use the new technologies that are introduced nearly daily into their practice environments. As a result, nurses may feel disorganized, tired, angry, and emotionally spent.

Nurses need to take care of themselves first so that they can be effective in their patient and family care. Caring for themselves involves conscious attention to their health and health practices. In addition, nurses have a "responsibility to model health behaviors" (Leonard, 2014, p. 17). They should ask themselves whether they eat a balanced diet, get appropriate exercise, and get enough sleep. Do they have strategies to manage stress appropriately and adequate social support? To what extent should health professionals model healthy behaviors? Reflect upon what While (2015) asserted: "The personal health behaviours of health professionals may influence how patients view their credibility as a health promoter" (p. 113).

An approach to improve health is to set goals and keep track of the progress. A website from the University of Minnesota (n.d.) gives information on well-being and a self-assessment tool as well as tips on setting goals. As part of a Concepts of Health course, students are asked to develop a personal health plan and to journal periodically during the semester about their ability to stick to the plan. Here is an example of a simple plan: "I will increase my intake of fruit and vegetables and walk outside for 30 minutes at least 3 times per week." As the students reflect on their ability to stick to the plan in the journal, caring for self is brought into conscious awareness. This simple self-reflective practice may be just the boost

that is needed for a nurse to commit to self-awareness and self-care on a long-term basis (**Figure 24-2**).



Figure 24-2 Reminder: Take Care of Yourself

One additional strategy that the authors share with students is a breathing meditative exercise from tai chi and qigong called the five-element breathing sequence. This meditative exercise, which can be performed in less than 10 minutes and can be very energizing and stress reducing, is described in **Box 24-1**.

BOX 24-1 TAI CHI AND QIGONG FIVE-ELEMENT BREATHING SEQUENCE

1. Stand with your feet shoulder-width apart. Relax your arms and shoulders.
2. Inhale slowly as you straighten and then move both arms slightly back and then up with palms facing up (as though you are gathering a giant ball of energy). Stretch to your full height as you inhale.

3. Exhale slowly as you press both palms down in front of you with hands slightly cupped and thumbs and index fingers nearly touching. Bend your knees slightly to sink down as you exhale.
4. Turn your hands over (palms up) just below the waist, and inhale slowly as you raise your hands in front of you, to chest height. Straighten your legs as you inhale. (Imagine lifting a ball of energy.)
5. Exhale slowly and extend the arms directly in front of you, chest high, and fan your hands open to release the energy in front of your chest. Bend the knees slightly to sink down as you exhale.
6. Inhale slowly, with palms facing you, to gather the energy back toward your chest. Straighten your legs as you inhale.
7. Press both arms straight out at shoulder height as you exhale. Pretend you are pushing on walls located on either side of you. Continue the exhalation as you bring your arms in front of you. Bend your knees slightly to sink down as you exhale.
8. Inhale slowly as you gather the energy to your chest. Straighten your legs as you inhale and stretch to your full height.
9. Exhale slowly as you raise your arms above your head to set the energy free. Bend your knees slightly to sink down as you exhale.
10. Transition your hands to the beginning to repeat the sequence by inhaling as you bring your hands halfway down and exhaling the rest of the way. (You can also end here by bringing your palms together in closure, first inhaling and then exhaling as you slowly move your hands down in front of you.)

Visit the following website for a demonstration of the five-element breathing sequence: www.youtube.com/watch?v=KtVCCLlkcKg.

The simplest and perhaps most effective strategy nurses can use to help them be fully present to their patients is to pause to take a few deep breaths to calm themselves and clear the clutter from their minds before they address each patient. Nurses' repeating a patient's name silently a time or two before they enter the room also helps. This practice, known as **centering**, enables nurses to "be available with the whole self and be open to the personal and care needs of the patient" (Penque & Snyder, 2014, p. 31). When nurses are with a patient, they must be certain that their mind is fully engaged in the interaction with this patient for the moment. They must be fully attentive to the patient, be both physically and mentally present, meet the patient where they are emotionally, listen

actively to what the patient is saying, focus on the nonverbal cues the patient is projecting, touch the patient gently and reassuringly, and demonstrate acceptance (Penque & Snyder, 2014; Zerwekh, 2006). Being present can be used in any situation where nurses are addressing the wants and needs of the patient. It is important not to force the encounter on the patient for the benefit of the nurses' agenda (Penque & Snyder, 2014).

Nurses may feel that they do not have time to focus on caring presence. Caring opportunities are replaced by the time it takes to input all the information into the EHR and complete the measurable outcomes that are expected of them. The elimination of face-to-face interaction with the use of telephones, home monitoring, and other forms of telemedicine makes utilizing a caring presence more challenging. The theory of nursing as caring describes caring "as the end, rather than the means, of nursing, and that caring is the intention of nursing, rather than merely its instrument" (Boykin & Schoenhofer, 2015, p. 342).

A related and similar concept for practicing presence—caring between—is described in the nursing as caring theory (Boykin & Schoenhofer, 2015). Consider, for example, that nurses experienced in caring for elders with congestive heart failure will have expectations and preconceived ideas about what they will find in a patient situation. These expectations may not allow them to really "see" the whole patient and their experience of the illness. *Caring between* "is a loving relation into which nurse and nursed enter and which they cocreate by living the intention to care" (Boykin & Schoenhofer, 2015, p. 344). Nurses need to enter the situation knowing the patient as a caring person. This knowledge will create an acceptance confirming the patient as caring. The nurse's responsibility is not in determining what is wrong or needed in another but rather to be present in the situation to know the patient as caring and to foster a patient-specific caring environment. Nurses need to come to know their patients both intuitively and scientifically. Medical technologies provide an objective view of the patient, and nurses synthesize this view with their own perspective (wisdom), which is based on their experience, education, and

intuition as applied to the patient's situation. Nurses must facilitate the caring encounter by helping patients to find words for their experiences to promote mutuality (Holopainen et al., 2019). This is the essence of caring.

One of the first skills nurses are taught in their basic nursing education programs is **active listening**. They are taught to get down to the same level of the patient, make eye contact, touch gently (if culturally acceptable), listen attentively and nod appropriately, restate and clarify what they heard, ask questions to seek additional information, listen for feelings that are not being explicitly stated, and use silence to encourage the patient to think and provide additional information to them (Watanuki et al., 2014; Zerwekh, 2006). These communication skills are fundamental to caring. Pause to reflect on the words of Garagnon and Roth (1999), who described the great limitation of language:

> *Between what I think,*
>
> *What I want to say,*
>
> *What I believe I'm saying,*
>
> *What I say,*
>
> *What you want to hear,*
>
> *What you believe you understand,*
>
> *What you want to understand,*
>
> *And what you understand,*
>
> *There are at least nine possibilities for misunderstanding*. (p. 41)

Nurses should ask themselves when the last time was that they sat on a chair at a patient's bedside to get to the same level as the patient. Even a brief sit at the bedside can communicate volumes about their availability and willingness to listen, and getting off their feet for a moment certainly feels good. Have they ever experienced a patient who became emotional because they looked at the patient instead of at the computer? Nurses need to think carefully about the potential barriers to active listening that technology might present.

Considering telephone encounters and eHealth, nurses must truly listen and be present to a patient whom they cannot see. What are some of the ways that these caring presence skills could be adapted for use in a telehealth encounter? What are the challenges of communicating at a distance yet being fully present for the patient?

The discussion of caring presence concludes with a definition of the **art of nursing** provided by Finfgeld-Connett (2008):

> *The art of nursing is the expert use and adaptation of empirical and meta-physical knowledge and values. It is relationship-centered and involves sensitively adapting care to meet the needs of individual patients. In the face of uncertainty, creativity is employed in a discretionary manner. Artful nursing promotes beneficent practice and results in enhanced mental and physical well-being among patients. It also results in professional satisfaction and personal growth among nurses.* (p. 528)

All nurses must strive for beneficent practice that atones for the potential disruptions to the therapeutic nurse–patient relationship that their use of technology produces. More recently, caring encounters have been described as communion-in-caring. "A genuine sharing defines caring communion—as an intimate connection in time and space, an absolute, lasting presence" (Tuppal et al., 2022, p. 526). Overreliance on technology creates tension in caring encounters, and nurses should strive for "a soul-felt, in-sync connectedness" (p. 530). Nurses should strive to "contribute to human flourishing, affirm self-growth, others' growth and the community transformation through communion-in-caring" (p. 532).

Reflective Practice

As professionals, nurses should be constantly mindful of the need for practice improvement. Zande et al. (2014) discussed ethical sensitivity as a type of practical wisdom. Ethical sensitivity is integral to high-quality care and clinical decision-making. They advocated for reflection on practice:

> *Taking daily practice of care as point of entry for reflection is a way to discern both explicit moral knowledge and tacit moral knowing. Nurses and other professionals can contribute to improvement on quality of care by creating opportunities to reflect on daily ethical concerns in an inter-professional team.* (p. 75)

Liberati et al. (2015) also advocated for the use of reflection to help professionals "observe their work from a different perspective. . . . Such an exploration may help providers to generate insights on how healthcare services, processes, and facilities could be modified to better respond to patients' needs" (p. 49).

One way for nurses to focus more specifically on their practice is to engage in reflective journaling (**Figure 24-3**). In the Concepts of Health course the authors teach, they ask students to complete a reflective practice assignment over a 6-week period. Students are directed to review concepts of caring presence and active listening and to commit to consciously using a strategy for 6 weeks. At 3 and 6 weeks, they are asked to complete the following reflective journal entry:



Attributed to Peter Drucker (1909–2005).

Figure 24-3 Reflective Practice

(Attributed to Peter Drucker [1909–2005])

1. Write a brief description of the presence and therapeutic communication approaches you tried in your practice for the past 3 weeks. Provide specific examples of patient situations in which you tried the approach.
2. Reflect on the following:

- What did you do well?
- Which behaviors and skills do you need to improve?
- How did you feel about the experience as it was happening? Did you plan thoroughly?
- Did you achieve your objectives?
- Which aspects of planning do you need to improve?
- How will this experience affect your future practice?

3. Which professional development needs have you identified after reflecting on your performance? Which strategies will you use to address these needs?

Students frequently report that they enjoy this experience and that the exercise helps to remind them why they were originally attracted to nursing. They describe experiences where they felt an authentic connection to the patient. They also report that after 6 weeks of consciously practicing the strategy, it becomes a part of their daily practice. Centering is the most frequent strategy that the students choose to practice. A recent exploratory study of reflection grounded in caring theory reported three main themes: "Reflection provides an understanding of caring by developing a language of caring, reflection provides an understanding of seeing and meeting the person behind the illness and reflection contributes to increased self-understanding and awareness of oneself as a caring nurse" (Jaastad et al., 2022, p. 4).

Caring in the Future

Virtual reality, augmented reality, 3D printing, nanotechnology, sensor technologies, AI, and robotics are but a few of the technologies that will affect nursing practice in the future. Instead of shuddering at the thought of these technologies, embrace the wonderful and positive effects, efficiencies, convenience (for both patients and nurses), and improvements in healthcare afforded by them. What will nurses' future practice look like? How will education experiences change? What new nursing roles might emerge? To what extent will patient roles, responsibilities, and behaviors change?

The TRETON (Tanioka et al., 2019), mentioned earlier in the chapter, may provide insight into the blending of technology and caring and how nurses' future might be shaped. As Tanioka et al. described, this middle-range theory attempts to guide practice and research when humanoid nurse robots (HNRs) or other disruptive technologies are part of the care environment. Transactions will occur between robots, between robots and patients, and between nurses and robots, with nurses mediating the transactions. "Through nursing, human engagements and technological engagements will be coordinated in the encounters between the HNRs and the persons being cared for" (p. 314).

The five key assumptions of the TRETON follow:

1. Nursing includes relationships between and among human beings and intelligent machines such as HNRs.
2. Nurses adopt technologies that aid the practice of nursing.
3. Intelligent machines possess AI that can mimic human interactions.
4. Human-to-intelligent machine relationships are technology dependent.

5. Transactive relationships are guided by ethics in nursing. (Tanioka et al., 2019, p. 315)

In the study, a case example was presented where a nurse utilized Nicki (an HNR) to monitor vital signs of a patient with congestive obstructive pulmonary disease and asked the robot to provide relaxation videos to the patient and to help the patient communicate with his daughter at a distance. All interventions by the robot were nurse directed. "The health care robot Nicki was programmed to be a functional partner-in-caring to provide functional services that were relevant to Mr. Thomas's needs as identified by the nurse" (Tanioka et al., 2019, p. 315). Medical technologies hold promise in addressing future pressing healthcare needs as the population ages and nursing shortages emerge. Can you think of a recent time-intensive nursing situation where you could have been assisted by an HNR?

Despite technological innovation allowing nurses to "know" their patients and providing efficiencies in care by performing routine tasks, nurses can and will continue to be central to health care by virtue of their ethical, caring, and advocacy functions. Patients will be empowered to be partners in their health care and will look to nurses to help them manage that power.

Summary

Nursing practice relies on information and communication technologies that receive inputs from the nurses as well as all the patient care technologies. Computers, handheld devices, monitors, and other healthcare technologies are essential tools for nurses. Therefore, the nurse must have the ability to implement, monitor, and evaluate this equipment based on its inputs and outputs. The increased demands on the nurse make it easy to lose sight of the patient amid all these technologies. Nurses must look at monitors, devices, and other gadgets to receive information; often, it is easy to forget that the patient is at the core of their care. Nurses should embrace these new technologies as assistants to help them fully know their patients.

The authors hope that this brief overview of caring presence prompts nurses to be more mindful of their practice and that they, too, will commit to employing strategies that enhance their caring presence in all patient encounters. Nurses do not want their patients to feel that they are more focused on the machines that the patients are connected to or the workstations that they bring with them to the patient encounter than they are on them. Yes, technology is great, and it does help nurses collect meaningful data and generate knowledge about their patient situations. But equally important is the need to collect the human-to-human data that become available only when nurses step away from the technology and interact authentically with their patients.

When you save a person's life—they call you a hero.

When you blend science with caring—they call you an expert.

When you share your compassion—they call you a friend.

When you do all three—they call you a nurse.

—Author unknown

THOUGHT-PROVOKING QUESTIONS

1. Examine each of the 10 caritas processes developed by Watson. Describe an example of a patient encounter that demonstrates the use of each caritas process.
2. Reflect on your personal health. Are you a role model for your patients? Which aspects of your personal health do you need to improve? Which strategies will you adopt to improve your health?
3. Choose a caring presence strategy to implement in your practice, and use the reflective journal template provided in the chapter to reflect on your practice.
4. Describe a patient scenario where you could enlist the assistance of an HNR. How would you introduce the robot to the patient? What duties or functions would you delegate to the robot? What care functions would you continue to provide? How would you convince skeptical colleagues of the value of the HNR?

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CHAPTER 25

Our Expanding Realities and the Metaverse

Craig McGonigle and Dee McGonigle

OBJECTIVES

1. Describe reality.
2. Differentiate between virtual reality, augmented reality, mixed reality, and extended reality.
3. Assess how informatics supports and evolves the realities.
4. Explore various realities to contemplate and critically think about in relation to your current reality and foreseeable realities while imagining your future realities.
5. Assess the relationship between Internet of Things (IoT), Intelligence of Things (IoT), and Artificial Intelligence of Things (AIoT) and reality.
6. Explore the effect of big data, robotics, and smart devices on our professional reality as well as on our patients' realities.
7. Describe the concepts of AI and the metaverse in relation to reality.
8. Assess the effect of the metaverse on our personal and professional lives.
9. Contemplate the effect of the metaverse on our patients, their care, and the healthcare delivery system.
10. Explore the concept of the metaverse and evaluate its future promise regarding nursing and nursing informatics

KEY TERMS

- 3D printing

- artificial intelligence (AI)
- Artificial Intelligence of Things (AIoT)
- augmented reality (AR)
- cyborg
- disruptive innovation
- extended reality (XR)
- fantasy
- haptics
- hologram
- human intelligence (HI)
- Intelligence of Things (IoT)
- Internet of Everything (IoE)
- Internet of Things (IoT)
- metaverse
- mixed reality (MR)
- proprioception
- reality
- robot
- smart device
- somatosensory system
- spatial audio
- telemedicine
- transforming
- virtual reality (VR)
- voice recognition
- wearable device
- wearable technology

Introduction

We wrote this chapter to give you pause to think about nursing in the context of informatics and, of course, reality. We designed it to challenge your foundation of knowledge and your reality. As you read this chapter, take the time to reflect on your own situational contexts, both personally and professionally.

You have expanded your information and knowledge about nursing informatics and how it affects practice and patient care. Now please consider informatics in relation to your reality.

Reality refers to the world or the state of things as they actually exist. When contemplating reality, is one person's reality different from another person's reality? If so, in what ways? Do people's experiences and education affect how they view the world or experience reality? If those questions do not pique your interest, perhaps this one will. When people enter virtual reality (VR), does that experience then become their reality, or do they suspend reality to enter **fantasy**? Augmented reality (AR) is an enhancement of people's reality. Does AR become their reality, or do they distinguish the changes as those that are added to their reality? If virtual, augmented, and actual realities are combined, what is real to the person?

Overview: Informatics and the Realities

Being able to distill big data into patterns and predictive models, along with the genome reality, has affected the way patients are treated; true patient-centric treatments and individualized plans of care can now be developed since the rise of personalized medicine. Here are some of the advancements that have enhanced patient care and transformed the healthcare reality:

- Exploring the patient's own anatomy using VR prior to surgery
- Seeing through the skin to illuminate veins for blood draws
- Using decision support technologies
- Using artificial intelligence (AI) for making decisions and interpreting diagnostic tests, analyses, and diagnoses
- Planning treatments
- Integrating smart devices
- Distilling massive amounts of data and research into meaningful doses
- Prescribing
- Assigning and revising adaptive learning modules based on the individual's learning cues
- Connecting through global telehealth
- Using robots
- Providing VR distraction for painful procedures

Informatics will continue to support the need to apply the information and technology garnered from experience to advancing developments. As technology continues to evolve, nurses will see different uses for that technology and its integration into mainstream health care and the educational arena. Informatics, which shapes the ubiquitous integration of technology, will continue to transform and alter nurses' reality.

Nursing Informatics and the Realities

Nursing informatics has enhanced the current reality of providing direct patient care while beginning to transect the realities of life given the current technological capabilities. From implementing **voice recognition** to improving the ability to interface with devices to entering total VR environments, technology continues to affect the nursing reality. In the healthcare arena, technology continues to push the envelope and challenge paradigms and abilities. Those who adopt and adapt the latest technologies available will continue to transform health care and provide patients with the most advanced care techniques.

The current technological changes pose tremendous challenges to and place great expectations on those educating the future healthcare workforce. Faculties must be early adopters and keep their students abreast of the technological advances made in health care and other sectors that will affect patient care. Future care providers, researchers, administrators, informaticists, and educators must be able to frame the use of technology. Practitioners must constantly strive to stay current with an eye to the future so that they are implementing the best technologies to improve patient care. Lifelong learning must not only be a search for knowledge but also a way to stay informed about new technologies and learn how to implement them. Going one step further, practitioners must use their new knowledge to better understand the technologies and, through their ideas, extend the capabilities of the technologies.

Nursing informaticists are engaged in evaluating and choosing technologies. They are responsible for tailoring functionality and establishing end user conditions and requirements. In addition, they are relied on to deploy the technologies and prepare users by designing and delivering the necessary training. As nursing informatics informs and expands nurses' knowledge and technology use, their reality is being affected as well as the reality of the healthcare industry and that of patients.

Realities

The current definition of reality is crucial to understanding the new realities and how they are **transforming** people's personal and professional lives. We will explore various realities to contemplate and critically think about in relation to your current reality and foreseeable realities while imagining your future realities. However, we must remember that each new invention, innovation, novelty, and advancement the future brings will cast everything we describe in a different light. Every newly expressed idea, concept, or product will continue to shape our reality.

The realities we will review are those that most people refer to, such as AR, mixed reality (MR), extended reality (XR), and VR. However, our commentary will go beyond the obvious to evolving developments that continue to have a profound influence on our realities, such as telemedicine; big data; and the **Internet of Things (IoT)**, **Intelligence of Things (IoT)**, and **Artificial Intelligence of Things (AIoT)**, including AI, robotics, smart devices, and haptics. These select technological enhancements are affecting our professional reality and have changed and will forever change the way we view the world of nursing and patient care.

Augmented Reality

Augmented reality (AR) is an interactive experience within a real-world environment that enhances real-world objects using virtually simulated or computer-generated perceptual information. It provides stimulation or input for multiple senses: olfactory; visual; auditory; haptic; and somatosensory, such as pressure, pain, and warmth. AR comprises apps; **wearable technologies**, such as glasses; and software that not only interacts with its users but also enhances their senses with data, information, audio, and images. The AR overlays are added to the users' existing environment or reality to enhance their virtual experiences.

AR innovations provide instantaneous access to patient data and information, which helps healthcare providers diagnose, create a plan of care, and implement the treatment regimen for their patients. As AR **holograms** infiltrate our reality, we can explore and manipulate these holograms with colleagues, such as in a learning space. AR holograms could be used to orient nurses and nursing students to a new work or clinical setting, such as a hospital. This orientation could be interactive and engaging by providing content that requires the active involvement of the learner as it teaches about equipment, patient rooms, and the physical layout of the healthcare setting. AR can overlay a patient in an exam room so that students can practice their patient engagement and interviewing skills. It can provide an anatomy or physiology overlay to explore and learn from as it brings objects to life right in front of students. AR can create a shared view, with everyone interacting with the same object at the same time. Even though a group may have a shared view, or AR object, are its members' realities the same?

Mixed Reality

Mixed reality (MR) is the blending of the physical world with the virtual world to create new environments and visualizations along the continuum from AR to VR. As students move from textbooks and two-dimensional images to the realities, they can now view anatomy from the inside out and explore it in three dimensions. Using MR decreases and even eliminates the use of cadavers. Nurses can practice complex procedures before they implement them with their patients. Has this already become the reality for some people in health care?

Extended Reality

Extended reality (XR) is an umbrella term where the *X* in XR can represent any letter so that the term covers all the forms of digitally altered realities that currently exist (i.e., AR, MR, and VR) and other

immersive technologies yet to be developed. With XR, users can experience augmentation through total immersion.

Virtual Reality

Virtual reality (VR) simulates reality in a digital medium. VR has been used in health care for about 20 years. Schools of nursing are exploring and implementing VR in the education of the future nursing workforce. VR learning episodes provide opportunities for nursing students to practice skills and interviewing techniques in a safe environment and experience intimate and challenging conversations, such as discussing death and dying with their patients while the faculty member assesses their ability to empathize with and support the patients. VR can be used to allow nursing students to become patients and experience the patients' reality based on their health status. The patients could have visual impairments, schizophrenia, Alzheimer's disease, or other conditions that become the students' reality. As the students cannot see well or slur their words or experience hearing voices, they become immersed in the reality of the patients they will be caring for. How does this VR immersion affect the students' reality when they interact with the actual patients? VR can be used to provide nursing students with the experience of patient care while interacting as a member of the healthcare team. Think of a nursing skill and the reality of the experience in VR versus the reality of performing the skill while providing actual nursing care. Advances in VR technology have been made that have enhanced medicine, such as surgeons' using the patients' own anatomy to practice a VR surgery prior to the actual operation. In this case, how is the surgeons' reality affected, and does the surgeons' VR reality affect their physical reality when they are performing the actual operation?

BOX 25-1 A GLIMPSE OF PATIENT EXPERIENCES IN FUTURE HEALTH CARE

As we go bounding into the next decade, we must consider human–technology interfacing as a confluence matrix where the human and the machine converge to create new realities. The humans are creating the software and machines necessary to enhance human capabilities. What does it mean to be human, and how are these lines blurring as our machines become intelligent influencers in this tenuous balancing act of a relationship? Because we are human, we tend to include the attributes of our humanness as we develop technologies. When technologies replicate, do they create images of themselves, and can they include human qualities? Must a machine behave like a human for us to accept it? How do we technologically enhance our bodies and minds without accepting the human–machine or human–technology integration? Is the machine or technology humanoid (i.e., appearance or character resembling a human)? Based on the number of enhancements, is there a point where we consider ourselves less human and more technology or machine? In the *Six Million Dollar Man* (a TV series that aired from 1973 to 1978), a man suffered severe damage during an accident and became the "bionic man." This bionic man was created by the melding of machinery and software with human tissues while maintaining his intellectual capabilities and humanness, or the quality of being human (i.e., human being or a person). As technology invades our culture and healthcare delivery system, what are the implications for future healthcare workers dealing with enhanced human patients or enhanced treatment modalities based on technological advancements?

What can we expect as our healthcare reality in the 2030s? It is difficult to answer this question given the rapid technological advances we are experiencing daily. We will present their interpretation of what the advancements will bring to health care in the next decade. In business, there are BHAGs, or big hairy audacious goals. For informatics, we provide our BHAG, or big hairy audacious glimpse, into the future.

TEENAGER: 3D PRINTING AND PROSTHESES

Mari Jaynea is a 17-year-old female who lost her hand in an auto accident. She wears a prosthesis that allows her to hold or grasp items, but because she is an active teenager, she frequently breaks her "fake hand," as she puts it. Her parents purchased a **3D printing** device that can make her prosthetic hand for less than $80 and print it out in layers in about 5 hours. Once the prosthetic hand has been assembled, Mari Jaynea and her mom test it to make sure that it fits well and that there are no areas of irritation. Now Mari Jaynea can have a new prosthetic hand quickly and more cost effectively compared to scheduling an appointment at the clinic and waiting for technicians to create it.

Mari Jaynea and her mom have joined the e-NABLE Community (http://enablingthefuture.org), which spans 100 countries. They now create prosthetic hands for two children in need who are within one hour's drive of their home. Mari Jaynea wants to reach out and find additional children her family can help. Her mom says that when she hears the printer turn on, she gets ready to assemble because she knows that Mari Jaynea or one of these other children needs a new prosthetic hand. Mari Jaynea has also joined an international innovative team created for the purpose of enhancing the printable prostheses. She will be testing new ideas, from printing and assembly to fitting and use. Mari Jaynea and her mother are excited to explore how they can improve Mari Jaynea's capabilities, comfort, and durability.

AN ELDERLY WOMAN, A ROBOT*, AND A SMART HOME

Amy is a 75-year-old female whose family is concerned about her staying in her own home alone. Based on her "forgetfulness," as described by the family, she can no longer drive because she went to the grocery store and forgot where her car was parked and then could not remember how to get home. They purchased a self-driving car for her that has all of her favorite spots, such as her church, grocery store, women's club, and YMCA, in its navigational system. It is also programmed for her nurse practitioner, hospital, hospitalist, and imaging and diagnostic centers. This vehicle is voice activated and equipped with emergency information for police, fire, and ambulance. Amy has a radio-frequency identification (RFID) chip in her arm that is recognized by the car and her virtual assistive service robot. This robot has a well-developed sense of smell and borders on instinct in its ability to detect issues in its human counterpart, in this case, Amy. Therefore, it easily replaces a service animal for the elderly or for those who do not or cannot take on the responsibility of animal care but who need the service. When Amy was introduced to her robot, it reminded her of a "Brad," so that is what she named it.

When Amy enters the garage, Brad accompanies her into the car. When Amy says "clothes," the car takes her to the clothing store. She will not order her clothes online because she has always shopped for them in person. She is appreciative that the clothing store has remained. Brad accompanies her into the store and carries everything she purchases, and everything is charged as they walk through the checkout station in the store. Brad contacts the vehicle to pick them up, and the car moves to the exit. When it arrives and is within 3 feet of them, it opens the doors and trunk. Brad makes sure that Amy gets in the car and then stows the purchases in the trunk and enters the car. Amy hesitates, and the car asks her if she is ready to go home. Amy says yes, and they return home.

Brad reminds Amy that it is time to monitor her heart, eat lunch, and take her medication. Brad has Amy go to the bathroom and then relax. It then proceeds to monitor her blood pressure and heart rate and checks all of her peripheral pulses; it determines that everything is normal and that this information does not need to be sent to her nurse practitioner. After lunch, Amy reads for a half hour and then Brad guides her through her exercises. Amy had a knee replacement and was rehabilitated using the orthopedic surgeon's treatment plan that Brad implemented. She is now on an exercise regimen that Brad initiates and monitors.

Amy told her daughter that Brad tells her the day, date, and news every morning and then lists the activities they have scheduled; she sees the nurse practitioner tomorrow. She states that she does not remember why they are going to see the nurse practitioner tomorrow and asks Brad to explain. Brad states that they had a telehealth appointment last month and the nurse practitioner requests a face-to-face meeting when necessary and at least once every 2 months. Amy says that she remembers that but asks why she has to go. Brad explains to Amy and her daughter Amy's medical condition and the results from this past weeks' monitoring and compares these results with the findings from the past year to show patterns and trends in Amy's health status. Brad explains Amy's medication changes and most recent health status, within the past month.

Amy wants to go for a walk with her daughter and asks Brad to stay home while they go. Brad scans her RFID chip and activates her wearable monitoring system to receive feedback about Amy on her walk so that it can intercede if necessary. Amy's daughter thanks Brad and says to Amy that she is well cared for by her virtual assistive service robot. Brad interfaces with all the smart home internet-connected devices while Amy is out of the house. Brad contemplates what is on the agenda for dinner today after checking in with the smart refrigerator. Brad monitors all of Amy's smart home devices to check their status. These are the smart devices currently in Amy's home:

- A stove that turns off if she leaves the kitchen and it is unattended
- A refrigerator that can create shopping lists, track expiration dates, and even create recipes based on the ingredients on hand. This information is transferred to Brad, which monitors grocery needs and meals in relation to Amy's nutritional requirements and meal and snack preferences.
- A slow cooker
- A coffee maker
- A washer, dryer, and iron
- All the locks on the exterior doors
- A doorbell with full audio and video capabilities
- The thermostat

- All lighting throughout the home that sets the ambient lighting based on the detection of Amy's presence in each room
- All outlets throughout the house
- All blinds, shades, and curtains throughout the house, which respond to Amy's settings based on the time of day and her presence in the room or location
- TVs that are voice controlled by Amy and Brad
- The garage door opener
- All security cameras, with audio- and video-capturing capabilities
- A commode that opens and lights up when Amy approaches
- Monitors that sense electric surges and turn off appliances or water issues, such as freezing pipes, and turn off the water to avoid a ruptured pipe in the house and flooding

Once Brad has checked the house, which it does twice a day, and scans Amy's monitors to make sure she is fine, it receives some downtime while waiting for Amy to return from her walk. Brad does not get much downtime, though, because Amy pings it to tell it to send the car because she is feeling tired. Brad provides her coordinates to the car and climbs in to get on its way to her while remotely monitoring her vital signs. Brad helps her into the car and scans her appearance while monitoring her vital signs again. Amy tells Brad she's just tired and to get her home. Her daughter gets in the car and off they go.

Amy walks into her living room and the lights turn on; then she asks the TV to tune to her favorite channel and sits in her recliner. The recliner moves to her programmed setting and elevates her legs. Brad asks her how she is feeling while monitoring her vital signs. Her vital signs remain normal, and Brad records the experience for their appointment with the nurse practitioner. Amy falls asleep, and Brad walks her daughter to her car. Brad enters the house, sets the doors to lock, and monitors Amy while she sleeps.

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*Reflecting on future care robots, such as Amy's virtual assistive service robot, Brad, does the robot's reality matter? What reality is programmed into the robot? If the robot is enhanced with AI, does it learn on its own and create its own reality?

Telemedicine

Telemedicine received a boost with the COVID-19 pandemic, which found healthcare providers scrambling to provide safe access to health care while maintaining quality and care continuity. Telemedicine necessitated regulatory changes that affected healthcare billing, and patients experienced a new reality using this healthcare access pathway. There are long-term implications for informatics, hospitals, providers, patients, and health technologies. Many view this reactive surge of telemedicine as the path forward, and it represents a paradigm shift in how care will be delivered beyond the 2020 COVID-19 pandemic. Reflect on these changes and the new realities generated from this evolution.

Big Data

Big data is mined, analyzed, and synthesized by informaticists who advance big data science. The informaticists must have access to data sets that are significant and relevant in order to mine them. Data mining occurs during the throughput in the middle of the data processing cycle. The Big Health Data Life Cycle, which is depicted in **Figure 25-1**, shows the path the data travel and how they are processed or transformed, from locating and capturing the data to interpreting and understanding the data to the reporting and ultimate use or application they inform.

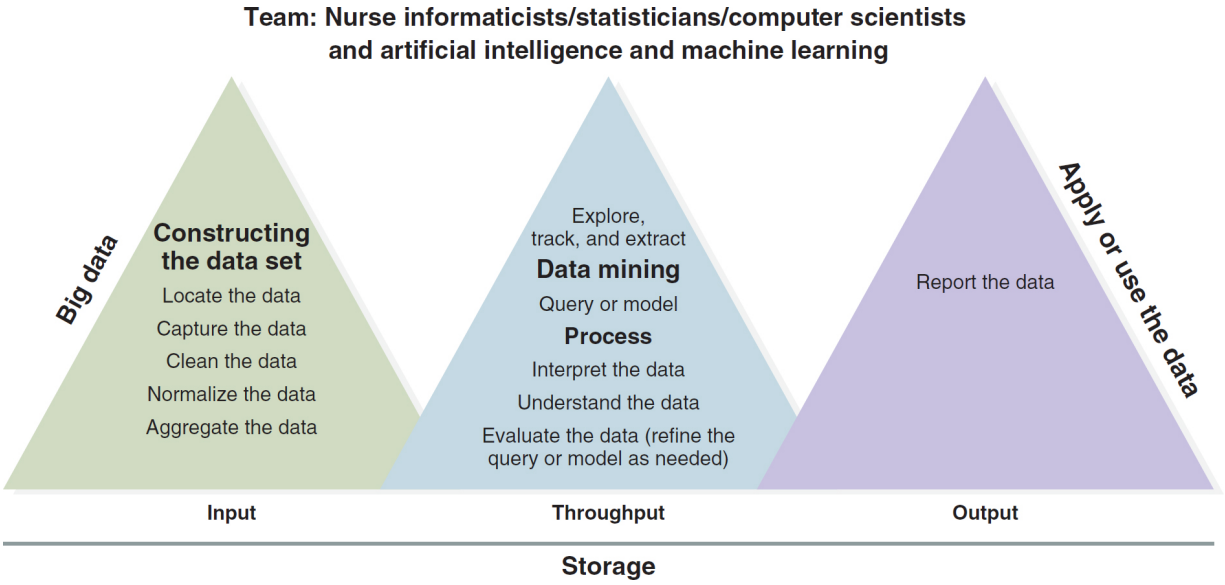


Figure 25-1 Big Health Data Life Cycle

Description

The nurse informaticist works with and often leads a team that typically consists of statisticians and computer scientists. Their ability to track and extract data and information in meaningful ways advances nursing knowledge and, when coupled with innovative, evolving technologies such as AI and machine learning, will have a significant effect on nurses' practice and the nursing profession.

Harnessing the gems gleaned from big data with cutting-edge technologies, models, and theories results in new knowledge and improved patient care; big data is informing and sculpting healthcare delivery. Patterns and trends can be identified in the data, patient outcomes compared to those expected, and predictive analytics and forecasting explored. As our skills and technologies advance, what we can gather from big data will continue to expand and inform us. Describe how big data changes our reality and that of our patients.

Internet of Things (IoT), Intelligence of Things (IoT), and Artificial Intelligence of Things (AIoT)

Technological advancements in science, telecommunications, robotics, and informatics capabilities in relation to technologies and big data continue to transform health care. The latest trail that is being blazed in the healthcare delivery system is from state-of-the-art, up-to-the-minute devices and the high-tech communication systems interfacing with and integrating them.

We know that the Internet of Things and AI are each self-sufficient in their own right and are potent technologies. The Internet of Things connects devices to the internet and to other interconnected devices that collect useful data and information. AI uses machine learning and intelligence to infer things and learn from its interfacing and interactions. AIoT is the blending of AI and the infrastructure of the Internet of Things to realize efficiencies and enhance human–technology interfacing and interactions. Through this powerful infusion, data management and analytics are improved. AIoT processes and transforms the data from the Internet of Things into meaningful information to inform decision-making. AIoT will be leading the way to empower the billions of smart devices and meet mainstream needs, including smart health care, smart monitoring, smart homes, smart self-driving vehicles, and other smart technologies that will contribute to society's health and lifestyles. AIoT will also assist with analyzing the data being processed. Our reality is changing because of the Intelligence of Things and AIoT, or applying AI to the Internet of Things, such as smart devices, monitors, and sensors; they not only communicate with us but also can interact with each other and even initiate actions based on data and information they collect from the devices in their Internet of Things, or interconnected network.

These devices can be proactive for our patients, which changes our reality. Typically, we react to patients who present with symptomology, whereas monitoring devices can be proactive when they detect subtle changes in the patient's condition, such as alerting patients to increase their intake of sugar or reaching out to the patient's healthcare providers in real time. Think of our reality in relation to information overload with the amount of data and information generated by humans now being augmented by AI-generated data and information. The AIoT infrastructure will allow us to realize efficiencies, enhance human–technology interfacing and interactions, and improve data and information management and analytics. We will consider AI, robotics, and smart devices because these advances are changing our world and our reality forever.

Artificial Intelligence (AI)

Artificial intelligence (AI) is a **disruptive innovation** that has exploded onto the scene (refer to Chapter 19, *Nursing Informatics and Nursing Education*, to learn more about AI's educational effect). AI-enhanced devices and agents are ushering in a new era of health care that will radically inform and enrich patient care and improve patient outcomes. AI's effect is far-reaching and ranges from using AI algorithms to monitor, diagnose, and treat a diabetic's fluctuations in blood glucose levels with insulin to providing real-time assistance for healthcare providers with clinical interpretation. The potential of AI in health care is being realized in its ability to interpret and diagnose. Radiologists' work will be greatly enhanced because AI can more efficiently and accurately interpret scans and X-rays than radiologists can. AI has been able to diagnose skin and breast cancers more accurately. AI and machine learning can extend the healthcare workforce. **Human intelligence (HI)** will coexist and fuse with AI as both intelligences work together to overcome the other's weaknesses while enhancing strengths. Reflect on how you could work with AI agents in your nursing role. How will this synergy enhance patient care and your role? How are patients' realities changed when they are being treated by machines and not people, as in the case of patients with diabetes whose blood glucose is being monitored and assessed and whose treatment is initiated by their AI agent? Healthcare providers who are struggling with patients' cases can seek assistance with interpreting the patients' data and diagnosing them. How can we illustrate an AI-enhanced reality?

BOX 25-2 CLOUD-BASED ECOSYSTEM

Meet Shandie, a woman with four children, a busy career, and an active lifestyle. She developed gestational diabetes during her pregnancy with her

third child, but it did not resolve after the child was born and is worsening and difficult to manage.

She works with Kevin, her nurse practitioner, to monitor her diabetes, but they have not been able to manage it given her family, career, and active lifestyle. Kevin tells Shandie that he has been trying to keep up with the medical data, which are constantly being released, and often consults with her endocrinologist, but they cannot keep up. He asks her whether she has purchased the smartwatch, which he prescribed, to monitor her lifestyle, blood glucose, and insulin needs. Shandie says yes and that she just sent information to him and her endocrinologist while she was waiting to see him. He praises her for being able to do that and states that it will help add vital data and information to assist them to help her. Kevin reviews the app that she is using and informs her that it is an AI healthcare cloud app; this tool will allow her smartwatch to provide them with data and information so that they can review all of her healthcare encounters and the personal data that she inputs. Kevin stresses that this will provide meaningful insights for him and her over time so that they can best manage her diabetes and address issues as they come up in real time with the built-in glucose monitoring.

Because the AI app functions in a cloud ecosystem, the environment is multifaceted and brings in a wide range of data, information, and knowledge from doctors, nurses, nurse practitioners, researchers, significant others (e.g., those people she trusts to answer questions and help monitor some of the app's output), insurers, pharmaceutical companies, and support groups. As the AI cloud apps share de-identified data and receive others' de-identified data to analyze, the AI learns and shares that output with everyone accessing that app. This information helps Kevin and Shandie compare her diagnosis, treatment, and situational context with others. Blending powerful analytics and insights, the AI app is able to make the best-informed recommendations for Shandie's care; as new studies and information or knowledge emerge, they are analyzed and synthesized into the app's AI, meaning that the AI is learning, expanding its capabilities, and sharing the output.

As this app interacts with an individual's data set, such as Shandie's, it can continue to learn about the situational context affecting Shandie's care and how treatment regimens have affected her health and ability to maintain her chosen lifestyle. As the app matures and other apps are created in the system, the data, information, and knowledge available continue to increase and be processed by the AI, as it can do best, and the clinician oversight helps to leverage what the clinician or human can do best to synthesize the AI's findings, recommendations with Shandie's needs, and situational context. As apps evolve and enter the ecosystem, how will our patient care reality change?

AI-POWERED HEALTH

Docus (2023) is an AI-powered health platform where you can "[t]alk to AI Health Assistant, generate your health report, validate it with a Top Doctor from the US & Europe" (para. 1). As more and more of these platforms become available to our patients, we must consider how much specific information they are able to access. It is one thing to seek information on the web about your condition or about general symptoms, but now patients can receive specific information about their contextual situation and about their own medical history, symptoms, and other factors that are relevant to them. In addition, the patient can choose to receive a second opinion from doctors from leading institutions from around the world. It is our responsibility to explore these platforms and help our patients navigate this new individualized information-seeking option.

AI GIVES PARALYZED WOMAN HER VOICE

A "[b]reakthrough brain implant and digital avatar allow stoke survivor to speak with facial expressions for first time in 18 years" (Marks & Kurtzman, 2023, para. 1). This patient is working with pioneers exploring AI algorithms to recognize unique brain signals for speech. This is such a positive reality changer for patients who feel trapped without the ability to communicate. The patient featured in this article described it as "[l]ocked-in syndrome" where "you are locked inside a body where no muscles work" (para. 9). This exciting research uses an avatar to add a face and personalized this patient's voice based on a recording she made prior to her injury. AI-enabled communications for stroke patients and others who cannot communicate will be extremely important evolutions to follow.

REFERENCE

Marks, R., & Kurtzman, L. (2023, August 23). *How artificial intelligence gave a paralyzed woman her voice back*. University of California San Francisco. www.ucsf.edu/news/2023/08/425986/how-artificial-intelligence-gave-paralyzed-woman-her-voice-back

Robots

Robots are automated and/or smart machines that are programmed to complete the routine tasks typically done by a person. Robots are permeating our healthcare delivery system. They assist with surgery; care for patients in place of nurses; and assume recurring tasks for nurses and doctors, such as getting supplies, to increase the time doctors and nurses can spend with their patients. They can assist in the pharmacy and deliver drugs and help the aged live more independently, as in the example of Brad helping Amy. Brad and robots that resemble pets can help with the psychosocial interaction lonely people need without the maintenance requirements of a pet or the risks of taking in a roommate. Brad helped prepare meals and monitored Amy's medications. What reality is programmed into the robot? If it is enhanced with AI, does it create its own reality? Do you foresee robots replacing nurses or augmenting and supplementing care in a future reality?

BOX 25-3 HOW WILL PATIENTS RESPOND TO CARE BOTS AND CYBORGS?

Chondon, a patient, enters the clinic, and a voice says, "Welcome to the Natural Coastal Waters Clinic. Please take a seat, and a care bot, NCW1, which is a robot that can assist with patient care, will be assigned to you during your visit today." Once seated, Chondon immediately sees NCW1 approaching him. It introduces itself as NCW1, the care bot that will be caring for him today, and asks him to accompany it to an exam room. On the way, NCW1 informs Chondon of his weight and height. They then enter exam room NCW1, the number of which corresponds to the care bot assigned to that room. NCW1 closes the door and turns to face Chondon; its chest opens, and a screen appears.

It says, "Welcome to our Natural Coastal Waters Clinic. To get started, please place the palm of your hand on the middle of the screen by placing it within the outline of the hand. Next, look directly into the soft blue light on the screen above your hand. I have your name as Chondon Smatty. Is it OK if I

call you by your first name, Chondon?" Chondon says yes and what the robot just did is amazing. NCW1 says, "Chondon, we now have a retinal capture. Your weight and height have not changed since your last visit, and I have obtained a set of your vital signs, which have already been transferred to your electronic health record and your smartwatch. All your vital signs are within normal limits. I have also assessed your blood glucose level, and it is elevated. The top of the normal range is 120, and your level is 140. I see that you are here to consult with Nurse Practitioner Kavan. Do you have any questions at this time?"

Chondon says, "Since when have robots been used here at the clinic?" NCW1 messages Kavan that Chondon is in his exam room while answering Chondon.

"We were placed into service just last week. Our purpose is to help the patients and nursing staff. How do you feel about the care I have provided thus far?"

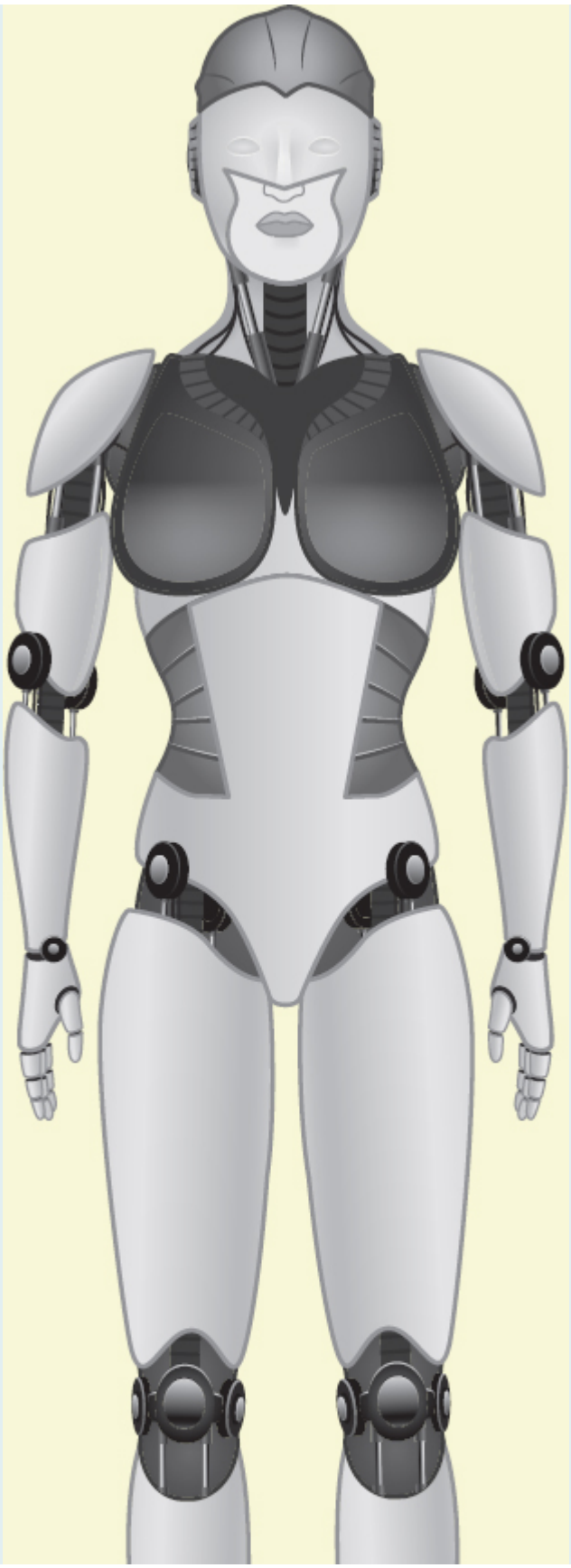
Chondon says, "I'm not sure; it's different interacting with a robot."

NCW1 corrects him by saying, "Care bot." Chondon smiles. Kavan enters the room to find Chondon and NCW1 chuckling together.

Kavan asks what he missed, and Chondon says, "I called it a robot, and it corrected me that it is a care bot. It's weird interacting with it."

This is when nurses must support their patients because their experience is different from when they come in for a visit. As a member of the nursing staff in this clinic, how would your and the patient's reality change?

Now fast-forward into the future. Chondon goes to the Natural Coastal Waters Clinic to meet with his cyborg nurse, CEN 1 (**Figure 25-2**). Chondon says, "You look human!" to which CEN1 replies, "I am a bionic human, a cyborg-enhanced nurse, or CEN, and I am the first one here at the clinic, hence my name CEN 1. Chondon asks what a **cyborg** is, and



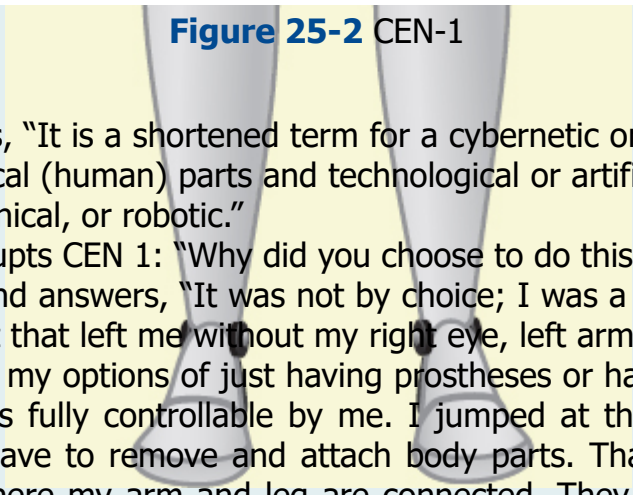


Figure 25-2 CEN-1

CEN 1 responds, "It is a shortened term for a cybernetic organism, cyborg. I have both biological (human) parts and technological or artificial parts that are electronic, mechanical, or robotic."

Chondon interrupts CEN 1: "Why did you choose to do this?"

CEN 1 smiles and answers, "It was not by choice; I was a nurse who was in a terrible accident that left me without my right eye, left arm, and left leg. The doctors discussed my options of just having prostheses or having the ability to use my new limbs fully controllable by me. I jumped at the chance to have control and not have to remove and attach body parts. That is why you see the metal skin where my arm and leg are connected. They also had a smart eye that they could implant. My face has the partial metal skin covering on my upper right cheek where there was too much tissue damage, and I chose not to have multiple surgeries. My face looks the same other than the black steel covering by my right eye. I have some mechanical organs and an artificially intelligent pancreas."

Chondon asks CEN 1 what its name was before the accident. CEN 1 states that "once my appearance was changed and I was listed as a cyborg, I wanted people to know I was a cyborg nurse, so my name is CEN 1; I feel as though I was given a new life after a devastating accident. I am thankful that we have the technology and science to do this. I can still practice as a nurse providing direct care to my patients. I know I confuse humans and care bots alike." CEN 1 laughs.

"There are other enhancements that I can share with you, but let's discuss why you are here and review your data strip." Chondon says, "OK, but I'll have more questions."

As a member of the nursing staff in this clinic, how would your and the patient's reality change?

Smart Devices

Smart devices (we would prefer another term, but "smart" is what is recognized in this reality) continue to invade our reality. If you have a smartphone or a smartwatch, how much do you rely on its capabilities to help organize your life? How much do smart devices communicate and share data with each other? Do you know how many steps you have taken today? Do you monitor your sleep habits, vital signs, and moods? Think back and reflect on your reality before you had these devices. In what ways did your reality change once you began using each device? Could you give up your smart gadgets? Our patients also use smartwatches. We can capture data from our patients' **wearable devices**, such as smartwatches. The data we collect and analyze from smart devices permit us to predict health problems and personalize treatment to support personalized medicine. We can treat patients before they even experience any symptomology. Consider all the smart devices you can describe and relate the types of data they can transmit to the healthcare provider. If we treat someone by providing them with access to an app, how does this reality affect our practice and change our and the patient's reality?

Haptic Technology: Reach Out and Touch Someone—Evaluating the Viability of Haptics

Haptics, the science of applying tactile sensation or touch to human–computer interactions, are technologies that can replicate and transmit the real-life sensations of touch in the virtual world using, for example, **proprioception** (body position and movement), force feedback, vibration, touch, temperature, and grasp.

Haptics work in much the same way as graphics and audio to shape our reality in the virtual world. Our **somatosensory system** is stimulated by haptics, which pass on context and other information to our brains. We are all familiar with haptics found in our phones and other electronic devices. The vibrate feature on phones uses haptics to provide a tactile response, letting us know we have an incoming call or a text without disrupting the people around us. Telehealth employs haptics because touch is an absolute necessity during patient assessment and diagnosis.

The future of haptics in nursing informatics looks bright not just for learners but also for patients. Haptics can simulate the resistance of the skin, blood vessels, and muscle tissue for giving injections, which means the more the learner practices, the more muscle memory the learner gains, resulting in better technique and confidence with much less discomfort and pain for patients. Haptics help assess edema. Strength tests, such as squeezing, can also be accomplished through haptics. What will haptics enable learners to do in 2030?

Transcending Reality—Exploring the Promise of the Metaverse

The term *metaverse* has been defined in different ways based on the definer's perspective. McGonigle and McGonigle (2023) stated that the metaverse is a concept and defined it as

> *the evolution of the latest frontier of the Internet that is a continuously accessible and available trisecting AI, the realities (MR: AR through VR), and our psychosocioeconomic digital and physical presence. The metaverse promises hyperconnected blurred or blended reality experienced through seamless immersive interactive exchanges on the devices we use from laptops to tablets to smartphones.* (para.7)

In simple terms, the **metaverse** is a virtual or digital place where users and their family and friends can learn, work, play, shop, and remain connected no matter where they are physically.

The promise of the metaverse as it is conceptualized is to provide the digital space needed to conduct our lives; it is a virtual or digital place where users and their family and friends can remain connected no matter where they are physically to participate in education, business, work/career, entertainment, socialization, mental and physical health, and wealth perspectives and events. This promise must be accomplished with a strong feeling of presence and being interconnected in a welcoming space where each user can control their own access and experiences. Users and businesses will be able to take themselves as their identities, assets including monetary assets, clothing, jewelry, furniture assets, and their experiences wherever they want to, and the digital spaces will persist or remain even when there is no one in them.

Refer to **Box 25-4**. What do you think of ChatGPT's description of the metaverse to a nursing student?

BOX 25-4 AI CHATGPT DESCRIBES THE CONCEPT OF THE METAVERSE TO A NURSING STUDENT

Dr. McGonigle asked ChatGPT, "How would you describe the concept of the metaverse to a nursing student?"

ChatGPT responded, "The concept of the metaverse can be described as a virtual space or world where people can interact with each other in a digital environment. It is a fully immersive, interactive, and interconnected virtual world where individuals can engage in activities, socialize, and even conduct business. It is essentially an online extension of the physical world where people can create and customize their own avatars and explore a vast and diverse digital landscape.

"For a nursing student, the metaverse has the potential to be used as a tool for healthcare education, research, and even patient care. In the metaverse, nursing students can participate in virtual simulations to gain hands-on experience with complex medical procedures, observe clinical scenarios, and learn from healthcare professionals in a safe and controlled environment. It can also be used as a platform for telemedicine, providing access to healthcare services to people in remote or underserved areas. Overall, the metaverse presents an exciting opportunity for the nursing profession to innovate and improve patient care through technology."

The Four Foundational Pillars of the Metaverse

To understand the metaverse, one must begin with the four foundational pillars of the metaverse: virtual environment, user experience, economy, and technology. Each pillar represents the fundamental elements or building blocks that make up the metaverse. These pillars are the key components that enable the creation and operation of the metaverse, and they play a critical role in shaping the overall user experience and moving us toward realizing the promise of the metaverse.

The first foundational pillar is the virtual environment that encompasses virtual real estate, infrastructure and connectivity, interoperability, continuity, persistence, and content creation and distribution. Everything has to do with the virtual space that supports open experiences. These environments can range from fully immersive 3D worlds to simple chat rooms.

Pillar 2, the user experience in the metaverse, is highly immersive and interactive and offers users a seamless and interconnected virtual world. Users can impact and be impacted by the metaverse. The user experience is engaging, encompassing avatar and object personalization, social and community presence and belonging, education or learning, health, wellness, and work experiences. Users can interact with a vast array of digital or virtual content as well as other avatars. AI will replace human-controlled actions and interactions with computer-controlled automated actions and interactions. AI avatars can learn gestures, body language, and language-specific conversational exchanges. AI avatars and objects can inform and assist people so that they can complete their tasks in the metaverse. Content is the crucial component of the metaverse, providing users with immersive and engaging experiences that can be user generated. Content is important since it "contains story reality, immersive experience, and conceptual completeness" (Ziaul, 2022, para. 19). The content is what the users want to experience and the reason they enter and interact within the metaverse. As

users generate the metaverse spaces, such as buildings, campuses, cities, houses, hospitals, offices, meeting spaces, clinics, streets, museums, or other assets, they choose the look and feel of the areas, how they are organized, and what services will be supplied. As people create their avatars with the look and characteristics they want for their avatar's appearance to represent them, the diversity of perspectives and culture will shape the community of the metaverse. Users or people as avatars are the subjects and the realities created within the metaverse and are the means for linking and connecting the avatars in the metaverse and the users in the real physical world. Users can engage in various activities such as socializing with other users, attending virtual events and concerts, playing games, exploring virtual spaces, and conducting business transactions.

The third pillar is the economy or virtual economy and commerce. Just as people can buy and sell goods and services in the physical world, they can do so in the metaverse, including the creation and sale of virtual goods such as clothing, furniture, paintings, and other digital items. In addition, virtual currency could be used to facilitate these transactions and potentially even be exchanged for physical currency. Blockchain is a digital ledger or database shared across a large network of nodes or computers. The nodes work together to authenticate and verify the transactions that are then stored and chained together in encrypted blocks of digital asset data. The more nodes that are running the blockchain, the safer and more secure it is since a hacker would have to hack more than half of the nodes to be able to make changes. Therefore, the blockchain forms a chronological verification for the data where the digital assets are distributed but not copied or transferred. Blockchain can support the decentralized infrastructure of the metaverse by providing extended storage capacity, trusted powerful data processing and authentication nodes, and interoperability across metaverse projects through seamless interactions and the sharing of related data, information, and resources. Commerce such as advertising and marketing will increase as people spend more time in virtual spaces. This provides opportunities for companies to market and sell products and services to the users. This could include targeted

advertising based on user behavior and interests as well as sponsorships and product placements within virtual environments.

Pillar 4 represents technology, and it is constantly evolving and improving. Technology is essential for creating a truly immersive and engaging virtual environment. The technologies include crypto wallets, point of sale, avatars, display technologies, digital assets, digital twins, digital representations, blockchain, 3D reconstruction, computer programs, VR and AR, AI and machine learning, cloud computing, gaming and entertainment, IoT, and the **Internet of Everything (IoE)**. The metaverse acts as a 3D user interface to the IoT devices, making possible personalized IoT user experiences where the user can make data-driven decisions with minimal training and expending minimal mental energy (Loth, 2022). The IoE is the intelligent connection of people, processes, data, and things where objects have sensors to detect, measure, and assess their status. The IoE affixes intelligence to the IoT and extends its communications from machine to machine and machine to people or users. Computer programs are those needed for the operation of the metaverse but also those that recognize and generate sights, scenes, and objects; recognize and synthesize sounds and speech; and output and render motions. The term *3D reconstruction* refers to the technology that supports the creation of photorealistic objects capable of capturing the realism for virtual spaces. Using 3D reconstruction, a company could create a virtual showroom for its cars where users can explore and even test-drive a vehicle.

These technologies will continue to play a crucial role in the development and growth of the metaverse.

These four pillars are the foundation supporting the move toward realizing the concept of the metaverse where users will be able to seamlessly move from one virtual world to another within an interconnected metaverse. It is not possible yet, as we currently have individual metaverses.

Use Cases: How the Metaverse Is Affecting and Will Affect Health Care

Individual users, as well as organizations, will have a profound effect on shaping the metaverse as they enter, explore, and demand more capabilities. To attract the users, the metaverse must be compatible with the user's social values, providing social meaning and the situational context for them. A metaverse might not be the real world but can elicit tangible emotions and feelings. For the metaverse to approximate the real world, the interactions must be seamless and concurrent within an environment with presence. Those born from the mid- to late 1990s through early 2010s are the upcoming generation, Gen Z, and their social values indicate that they want to move through the realities of their lives with their online and offline persona or presence being the same.

The following use case examples (**Table 25-1**) demonstrate how educational, healthcare, and insurance-based organizations are entering and pushing the limits of the metaverse technologies to provide innovative, immersive, and engaging educational, clinical, financial, and recreational experiences in a secure environment that maintains privacy. Time will tell how far the metaverse can go under the influence of the enterprises and their constituents.

TABLE 25-1 Metaverse Use Cases

	Education/Learning	Practice/Care
Nursing and other healthcare professional students	The future healthcare workforce must be exposed to the latest technologies in their educational journey. The use of immersive simulations representing different settings, patient populations, and technologies	Immersive simulations not only allow practice time prior to entering the actual clinical arena with real patients but can also expose students to infrequent patient

	must be used to prepare a career-ready graduate entering the future healthcare workforce. These same immersive settings can be used for telehealth experiences with actual patients. Students will learn how to interact with, navigate, and harness the power of the metaverse. Use cutting-edge MR and AI disruptive technologies to prepare practice-ready graduate nurses for the technology-laden clinical settings and for high-stakes, real-world scenarios. Create digital twins of actual campus settings or hospitals to help students become familiar with their learning settings.	presentations and events that cannot be done in the physical world such as disaster preparation. Provide clinical experiences using immersive learning simulations. Just as we seek clinical placements for our learners, we can create immersive environments that mimic our clinical settings to provide the necessary learning experiences. 1. Provide patient interactions through immersive VR settings to prepare students to interview and care for their actual patients. 2. Integrate competency-based experiences and assessments using VR and AI to evaluate competence and practice readiness, from clinical judgment and decision-making through performing select procedures in a safe environment without risk or harm to patients (American Nurses Foundation, n.d.). 3. Immersive experiences directed at the affective domain to teach sensitivity and empathy where learners become the patient to really experience their

			situational context (Brown, 2022). 4. Use AI-enhanced avatars as standardized patients. 5. Develop infrequently seen patient presentations using VR and AI for practicing nurses so that they can remain competent to provide setting-specific care.
Healthcare professionals	Immersive simulations can be used to maintain professional competency in the healthcare workforce not only in their clinical knowledge and skills but also in their knowledge and skill in the use of emerging technologies.		Enhanced patient safety. Immersive learning episodes can virtually simulate patient care encounters, allowing professionals to practice and hone their skills so that errors are reduced and time to treatment is expedited. In the surgical suite, surgeons can do the following: 1. Explore the patient's own mapped anatomy using VR and practice the surgery prior to operating on the actual patient. 2. Meet with other specialists in a virtual operating suite to collaborate and practice an upcoming surgery or during the actual procedure.

		Nurses can do the following: 1. Facilitate pain reduction through the use of VR technology instead of using medication. 2. Distract patients during long and/or painful procedures to enhance patient comfort. 3. Provide patient care by introducing apps such as those that help patients remember when to take their medications. 4. Provide immersive learning experiences for caregivers to prepare them to care for their significant others after discharge. 5. Introduce patients and their significant others to AI-powered agents that can help them monitor and improve their health status.
Patients	They can experience immersive learning episodes in consultation with their healthcare providers. They can acquire and use apps and AI agents.	Seek care via telehealth visits and consultations with healthcare providers they would normally interact with as well as top nursing and medical experts from around the world as the metaverse restructures, redesigns, and reimagines the provider–patient relationship and experience.

		Opportunities for wellness include diet; stress relief; fitness initiatives; and cues for treatment compliance, including medication dosage and time reminders.
Healthcare settings	Metaverse hospital systems could provide virtual offerings that mirror brick-and-mortar facilities for patients and healthcare providers.	Metaverse hospital systems could offer the following programs using MR: 1. Telehealth 2. Wellness 3. Educational episodes that not only foster patient–provider relationship building but also provide just-in-time learning for both healthcare professionals and patients 4. Collaborative opportunities that enhance the healthcare team as well as the provider–patient dyads involvement
Financial	Cryptocurrencies will be established by 1. hospitals for patient fees when accessing virtual and/or physical care; and 2. learning organizations for student fees and faculty/staff salaries.	Insurance companies must 1. determine how they will track, manage contracts, manage claims, and reimburse for metaverse or virtual healthcare visits in relation to how this is done for physical care episodes; 2. establish specific coding for the metaverse virtual sessions; and

		3. use their own avatars to serve their customers by a. approaching those insured and companies in the metaverse; and b. providing immersive experiences such as procedure options and hospitalizations. Learning organizations must do the following: 1. Develop cryptocurrency processes for collecting student fees and paying faculty and staff salaries. 2. Petition financial aid to consider and support metaverse offerings for their students.
Privacy and security	Blockchain will be used to protect records and data.	Both healthcare and educational organizations will use blockchain and other technologies such as facial recognition to protect, secure, and manage the sharing and exchange of patient data with healthcare providers and third-party payers and student data. Encrypted AI algorithms can recognize the patient and/or student.

Challenges Facing the Realization of the Metaverse

As we enact use cases and strive to realize the promise of the metaverse; persistent accessible hyperconnected psychosocioeconomic digital and physical presence; or where we can learn, work, play, and shop no matter where we are physically, there are challenges that we must recognize and be able to overcome. This brief discussion will begin with the challenges facing everyone using the metaverse, including nurses, and will include nursing role–specific considerations (**Table 25-2**).

TABLE 25-2 Nursing Role–Specific Challenges

Nursing Role	Challenges
Nurse educator	Nurse educators must learn about the metaverse and its disruptive capabilities in order to have input and shape this new frontier by analyzing and synthesizing the evidence surrounding the metaverse pedagogy. They must identify and intentionally incorporate the best educational practices; immersive learning experiences; and significant, meaningful interactions to advance and develop an educational or learning metaverse. These educators must be able to help their administrators and other educators gain the expertise necessary to drive and harness the metaverse's teaching and learning potential. To accommodate learners with disabilities, they must find ways to address disparity with technological enhancements. If they provide a VR experience that some of the students cannot access and complete, how do they develop an alternative assignment that is comparable to the immersive and engaging VR episode? They must keep in mind that the learning must be

Nursing Role	Challenges
	equitable and of high quality but that it does not have to be equal.
Nurse in clinical practice	Nurses in clinical practice must develop the expertise necessary to 1. develop metaverse solutions that not only improve patient outcomes but also enrich the nursing profession; 2. assist other healthcare professionals with patient-care strategies for the metaverse; and 3. help their patients understand and be able to navigate the metaverse to receive all three levels of prevention: primary, secondary, and tertiary.
Nurse researcher	Nurse researchers must find ways to engage with and study patients as they experience the metaverse. How can researchers truly track patients as they move about the metaverse? How will patients seek care? Will they experience the levels of prevention from different entities in the metaverse? Will they want or demand care in the metaverse versus physical care? Will there be separate institutional review boards (IRBs) for the virtual metaverse side of the institution versus the actual institution? Can one IRB approval be accepted by more than one virtual institution in the metaverse or between the real and virtual institutions?
Nurse informaticist	It is imperative that nurse informaticists protect the security of patient data and information in the metaverse. As they rely on technologies and seamless transitions in the metaverse, they must remain vigilant in finding solutions that maintain their patients' privacy. It is important for them to 1. find ways to streamline digital procedures; 2. constantly inform policymakers on the updates necessary to keep pace with the evolution of the metaverse; 3. prepare others for accessing, entering, and using the metaverse to enrich their personal and professional lives,

Nursing Role	Challenges
	especially nurses and other healthcare professionals providing patient care and supporting metaverse-based care initiatives; 4. realize that hardware plays a key role in the immersive experience and can be an obstacle to reaching the full potential of the metaverse as well as collaborate with hardware vendors to advance their products to meet the needs of the evolving metaverse in relation to patient care and healthcare professionals, compentency; 5. collaborate with software vendors to develop software programs that are needed to interface with hardware and advance the metaverse frontier; and 6. actively participate in the efforts necessary to realize the promise of the metaverse for themselves, other healthcare professionals, and patients and their significant others.
Nurse executive	Nurse executives must 1. learn everything they can about the metaverse and how it will impact their practice settings; 2. afford professional development to the nurses under their supervision; 3. create collaborative interdisciplinary teams to address the needs of their practice settings, especially as they relate to interoperability and the ability to securely share data and information; 4. advocate for the commerce of the metaverse with their administrative peers; and 5. advocate and prepare for the commerce of the metaverse with the integration of blockchain technology and cryptocurrency to secure monetary exchanges from patients and third-party payers.

The relationship between the IoT and the metaverse is becoming evident since one of the greatest challenges for the metaverse lies in its ability to access, correlate, and map data and information from the real world and meld it into the digital or virtual reality. This data

and information must have meaning and be secured, accurate, organized, and available synchronously, in real time. Since the IoT has been around and in use for several years, there are hundreds of devices, including cameras, wearables, and sensors, that are available and ready to be used and incorporated into the metaverse. All nurses must assist policymakers in expanding their policies to handle the rapid evolution of technologies and capabilities that are and will be afforded as the metaverse develops. Policies typically do not keep pace with technological evolution and capabilities, and the evolution of the metaverse is no exception. For example, the Health Insurance Portability and Accountability Act (HIPAA) guidelines have tried to keep up with the expansion of telehealth and mobile computing; however, the metaverse has now entered the patient care arena, and lawmakers will need a wide variety of expert input, including from nurses, to help them understand and modernize the necessary guidelines based on the abundance of data and information in the metaverse. In addition, governance of the metaverse will be essential, which requires the establishment of a set of unified rules. Copyright and ownership issues must be addressed legally. Software and hardware vendors need help in understanding the metaverse frontier to create the products, programs, and devices that will meet the users' current needs and current state of the metaverse with an eye to the future. As with any digital platform, malicious activity and attacks that breach security will be an ever-present threat that could cause ethical issues, loss of data and information, invasion of privacy, harassment, and intentional human rights infringements, to name a few. With the metaverse capabilities, users might suffer risks of physical harm from the prolonged use of wearable technologies, especially the HMDs or headsets, during their immersive activities. As with any socially interactive space, there are risks of emotional and psychosocial harm, whether intentional or unintentional. When dealing with a new frontier, everyone must be vigilant to maintain access and equity. Since the metaverse is presenting us with an enormous evolution of the internet, issues with interoperability and scalability must be recognized and addressed. For the metaverse to

be viable, we must have the ability to exchange, use, and share data and information on a grand scale and to handle the expanding volume and workload. AI agents will need to be enhanced to improve and personalize the user experience by providing meaningful just-in-time assistance or information. Infrastructure improvements must be made to ensure reliable and persistent availability. There must be a secure system in place to be able to make payments for services or products in the metaverse. Blockchain and cryptocurrency (i.e., a method of digital payment using blockchain technology) must be implemented in which blockchain is a digital ledger that overcomes the weaknesses of centralized data storage by providing a secure means to create, own, and monetize decentralized digital assets.

The weaknesses and threats in the metaverse become challenges that must be eliminated, such as confidentiality issues, interoperability problems, privacy invasion, security breaches, faulty navigation, and seamless transitioning between the real world and the virtual or digital world as needed. There are many challenges to address as the metaverse evolves. It is important to keep an eye to the future while being grounded in the present as we strive to have the metaverse approach real-world exchanges, the seamless and concurrent interactions gained through presence, interfaces, and connections. As the metaverse mimics the real world, it can elicit or cause real emotions and feelings as people are immersed and present in their digital experiences. As more nurses and nurse informaticists learn about, research, and experience the metaverse, they must realize the effect they can have in shaping this new frontier for improving patient outcomes, enhancing their professional development, and advancing the nursing profession. Nurses and nurse informaticists must educate other nurses, patients, and the healthcare team as to how to leverage the benefits of the metaverse. Nurse informaticists must assess the effect of this new frontier on their own practice setting while helping other nurses and healthcare team members understand the technologies, functionality, and capabilities of the metaverse so that they can enhance their practices and support their patients. It is imperative

that we determine how the nursing informatics specialty will influence and be affected by the metaverse. As we push the metaverse envelope and continue to create the cutting edge of this frontier, we must always be vigilant against security and privacy issues, access and entry equity, and persistence. It is every professional's responsibility to access, enter, and navigate this new evolution of the internet so that they can harness its potential for the benefit of the patients under their care. Nurse informaticists and nurses must recognize and address the challenges as they arise during the evolution of the metaverse frontier.

In conclusion, the idea of the metaverse is not new, but technological advancements have brought about changes in our capabilities, enabling more realistic virtual worlds moving toward realizing the promise of the metaverse. Second Life, largely regarded as the first metaverse, was launched in 2003. Its features are too robust to cover here. However, it built the foundation from which the new metaverses are constructed since they employ much of the same features, from spatial audio to interactions with others. **Spatial audio** is the capability to direct how the user experiences sound to mimic the real world. Educators, business owners, and everyday people enjoyed the Second Life metaverse to work, make money, or relax from real-life stressors. Rumors on the internet suggest an update is coming for this older platform, enabling the use of VR along with today's advancements.

Metaverses are designed to extend the users' reality; they can replicate reality in a virtual environment that it is as close to the real world as possible, thus allowing users to interact as they do in the real world while providing a safe environment. As our capabilities are enhanced, will we see more genuine actions, such as the use of haptics for handshaking and other greetings, incorporated into the metaverse to enhance realism? What other experiences can we expect to see in the next 3 months, 6 months, 1 year, and 2 years?

Summary

Throughout this text, you have explored the field of nursing informatics and its effect, influence, and transformative powers in the healthcare arena, patient care innovations, and the nursing profession. As we are informed through the use of nursing informatics and expand our knowledge and technology-infused practice, we affect our reality, the reality of the healthcare industry, and the reality of our patients.

Through the application of knowledge, technologies, and nursing informatics, disruptive forces transform reality and disrupt the healthcare industry. We must make sense of and meet the challenge of this disruption. Personalized learning is disrupting how we conceptualize nursing curriculums and learning episodes. Forces beyond our control, such as the COVID-19 pandemic, disrupted our reality with governments mandating social distancing, quarantining, and isolation. In addition, disruptive innovation has changed the healthcare landscape.

Our reality is described and experienced through our own perceptual screen. We now have tools that provide us with different realities that we experience to the extent that we engage with them. Our reality related to health care and nursing will continue to be shaped by advancing knowledge and technologies.

The metaverse is not just a new trend or an improvement in existing technology. It is a paradigm shift in content consumption, which nurses and nurse informaticists must lead. The metaverse is emerging as an immersive technology with enormous potential for optimizing patient care across the entire healthcare continuum. We encourage everyone to join as participants in new paradigms that will disrupt and influence the future of health care and our professional and personal lives. We must participate so that our practice settings, patients, and profession have a place at the table. The metaverse is composed of many different elements in which the users' input and creativity are essential. It is believed that the future

does not depend on the developers as much as the users, who can actually shape every facet of this new internet frontier. There will be ongoing challenges and issues that we must address since there will be many new, shifting dimensions of the metaverse. By anticipating and preparing to mitigate potential pitfalls and creating a patient-centered collaborative setting, healthcare providers in the metaverse will generate better expectations for this immersive and unparalleled frontier as they engage their constituents and colleagues to improve healthcare delivery. Of course, we have only scratched the surface, but we wanted to give you a glimpse of how our professional and personal lives will change with the innovative disruption in our healthcare arena that is challenging our paradigms and rapidly creating new ones—new ways of thinking, working, and learning.

Is reality as simple as how we as humans interact and make sense of different phenomena? If the phenomena include technology, how do these phenomena change our frame of reference and affect our reality? Do we see the technologies as mere tools we use and then return to the reality before their use, or do they truly become part of our reality and influence our worldview? Just as the concept of the metaverse has risen to the forefront and AI exploded onto our digital landscape, what will disrupt our reality next?

We would like you to contemplate the following notions:

- What will our reality be as a
  - healthcare professional,
  - patient,
  - layperson,
  - learner preparing for entry into the workforce, or
  - lifelong learner practitioner?
- Can we share our realities?
- How will we share our realities?
- Can we experience a shared reality?
- Will each setting have its own reality composed of the collaborative realities of the healthcare providers and the

patients and the knowledge and technologies they use? Will each person have their own reality created by this interaction? What are the commonalities? What causes the differences?

- How will informatics influence, create, support, evaluate, and revise the realities of the future?
- What will you do to influence, create, support, evaluate, and revise the realities of the future?
- Just as we are concerned about access to health care, what about access to the realities?
- Will there be levels of reality and immersive depths?
- How will we prepare for these realities?
- In our personal lives, how will our realities be defined? Will they be perceived, constructed, created, crafted, designed, interpreted, rethought, or shared?
- Do we have multiple realities? Can there be multiple realities throughout a day, such as the reality of work and the reality of transportation home, and then, when we return home, the reality of being a parent, roommate, daughter, son, and so on? Do we move in and out of realities, or are all of these realities our total reality? What about when you don your headset?
- Will AI create our reality for us?
- Will we realize the promise of the metaverse?
- How do the individual realities of nurses transform the reality for nursing?
- How do nurses realize a transformed reality for health care?

THOUGHT-PROVOKING QUESTIONS

1. What is your current reality? Describe reality from your perspective and how your reality affects your patient care.
2. What will your nursing reality look like in 1 year, 5 years, and 10 years? Provide a detailed description of how your reality will change.

3. What will the reality be for our patients entering the healthcare system in 1 year, 5 years, and 10 years? Provide a detailed description of how their reality will change.
4. Just as we have disruptive innovation, do we have disruptive reality? If so, describe it in detail.
5. Reflect on AI and its effect on reality. Can and will AI craft our realities for us? Is AI part of our realities? Explain your answers in detail.
6. Assess the concept of the metaverse. What is the reality of the metaverse, and how can we realize its promise?

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Abbreviations

3D three dimensional
ABC alternative billing codes
ACLS advanced cardiac life support
ADT admission, discharge, and transfer system
AEMR academic electronic medical record
AHRQ Agency for Healthcare Research and Quality
AI artificial intelligence
AIoT Artificial Intelligence of Things
ALA American Library Association
Alt alternate key on the computer keyboard
ALU arithmetic logic unit
AMIA American Medical Informatics Association
AMOLED active-matrix organic light-emitting diode
ANA American Nurses Association
ANIA American Nursing Informatics Association
ANSI American National Standards Institute
APA American Psychological Association
API application programming interface
APM Alternative Payment Model
app application
AR augmented reality
ARG augmented-reality game
ARRA American Recovery and Reinvestment Act

ATSDR Agency for Toxic Substances and Disease Registry
b bit
B byte
BCMA barcode medication administration
BD2K big data to knowledge
BI bioinformatics
BIOS basic input/output system
BMP bitmap image
bps bits per second
BRFSS Behavioral Risk Factor Surveillance System
BTC Bitcoin
CAI computer-assisted instruction
CART classification and regression tree
CASE computer-aided software engineering
CBIS computer-based information system
CCC clinical care classification
CCL cardiac catheter lab
CD compact disk
CDI clinical documentation improvement
CD-R compact disk-recordable
CD-ROM compact disk read-only memory
CD-RW compact disk-rewritable
CDC Centers for Disease Control and Prevention
CDS/CDSS clinical decision support/clinical decision support system
CE continuing education
CHESS Comprehensive Health Enhancement Support System
CHF congestive heart failure
CHI consolidated health informatics
CHIP Children's Health Insurance Program
CI cognitive informatics
CINAHL Cumulative Index to Nursing and Allied Health Literature
CIO chief information officer
CIS clinical information system
CMIS case management information system

CMP civil monetary penalties

CMS course management system; content management system; Centers for Medicare and Medicaid Services

CNPII Committee for Nursing Practice Information Infrastructure

COPD chronic obstructive pulmonary disease

CPG clinical practice guideline

CPOE computerized provider order entry

CPU central processing unit

CRA community risk assessment

CRT cathode ray tube

CRYPTO cryptocurrency

CSP cloud service provider

CSS cascading style sheets

CTA cognitive task analysis

CTO chief technical officer; chief technology officer

Ctrl control key on the computer keyboard

CWA cognitive work analysis

DaaS device as a service, device as a managed service, or desktop as a service

DBMS database management system

DDR SDRAM double data rate synchronous dynamic random-access memory

DHIS Division of Health Informatics and Surveillance

DHR digital health record

DLP data loss prevention

DLT distributed ledger technology

DPI dots per inch

DRAM dynamic random-access memory

DSDM dynamic system development method

DSL digital subscriber line

DSS decision support system

DVD digital versatile disk; digital video disk

DVD-R digital video disk-recordable

DVD-RW digital video disk-rewritable

DW data warehouse

EB exabyte

EBP evidence-based practice

EDA exploratory data analysis
EDI electronic data interchange
EEPROM electronically erasable programmable read-only memory
EHI electronic health information
EHR electronic health record
EID ecological interface design
EIS executive information system
ELSI ethical, legal, and social implications
eMAR electronic medication administration record
EMR electronic medical record
ePHI electronic protected health information
EPA Environmental Protection Agency
ERD entity relationship diagram
ERIC Educational Resources Information Center
ERP enterprise resource planning
ESC escape key on the computer keyboard
ESLI ethical, social, and legal implications
F key function key on the computer keyboard
FLOSS free/libre open source software
F/OSS or FOSS free/open source software
FHIE Federal Health Information Exchange
FMEA failure modes and effects analysis
FPROM field programmable read-only memory
FPU floating-point unit
GAO Government Accountability Office
GB gigabyte
GDC Genomic Data Commons
Gen Z Generation Z
GHz gigahertz
GIS geographic information system
GLBA Gramm-Leach-Bliley Act
GUI graphical user interface
HAI healthcare-associated infection
HCI human–computer interaction

HCT human–computer technology
HDMI High-Definition Multimedia Interface
HET human enhancement technology
HGP Human Genome Project
HHA home health agency
HI human intelligence
HIE health information exchange
HIPAA Health Insurance Portability and Accountability Act
HIS hospital information system
HIT health information technology
HITECH Health Information Technology for Economic and Clinical Health Act
HL7 Health Level 7 International
HMD head-mounted display
HMIS health management information system
HMO health maintenance organization
HTI human–technology interaction
HTML Hypertext Markup Language
IaaS infrastructure as a service
I/O input/output
IoE Internet of Everything
ICNP International Classification of Nursing Practice
IDE integrated drive electronics
IEEE Institute of Electrical and Electronics Engineers
IHI Institute for Healthcare Improvement
IHIE Indiana Health Information Exchange
IM instant message
IN informatics nurse
INS informatics nurse specialist
iOS iPhone operating system
IoT Intelligence of Things; Internet of Things
IP Internet Protocol
IPS LCD in-plane switching liquid-crystal display
IS information system
ISO International Organization for Standardization

IT information technology
KB kilobyte
KDP knowledge domain process model
KMS knowledge management system
KPI key performance indicator
KWS knowledge work system
LAN local area network
LCD liquid-crystal display
LMS learning management system
LOINC Logical Observation Identifiers Names and Codes
LOS length of stay
LTC long-term care
MACRA Medicare Access and CHIP Reauthorization Act
MAN metropolitan area network
MB megabyte
MCIS managed care information system
MDS minimum data set
MERLOT Multimedia Educational Resource for Learning and Online Teaching
MHDC Massachusetts Health Data Consortium
mHealth mobile health
MHz megahertz
MIPS Merit-based Incentive Payment System; millions of instructions per second
MIS management information system
ML machine learning
MMIS Medicaid management information system
MMORPG massive multiplayer online role-playing game (sometimes shortened to MMO)
modem modulator–demodulator
MOO object-oriented multiuser dungeon
MOOC massive open online course
Moodle modular object-oriented dynamic learning environment
MoSCoW must have, should have, could have, and would have
MP3 MPEG-1 Audio Layer-3
MP4 MPEG-4 Audio Layer-4
MPEG Moving Picture Experts Group

MPI master patient index
MRI magnetic resonance imaging
MU meaningful use
MUD multiuser dungeon
MUSH multiuser shared hack, habitat, holodeck, or hallucination
NAM National Academy of Medicine
NANDA-I NANDA International, Inc.
NCATS National Center for Advancing Translational Sciences
NCPHI National Center for Public Health Informatics
NFC near-field communication
NFCIP-1 Near Field Communications Interface and Protocol
NFCMA near-field communication–enabled medication administration
NFT non-fungible token
NGC National Guideline Clearinghouse
NGI Next Generation Internet
NHANES National Health and Nutrition Examination Survey
NHII National Health Information Infrastructure
NHIN Nationwide Health Information Network
NHQR National Healthcare Quality Report
NI nursing informatics
NIC Nursing Intervention Classification; network interface card
NIDSEC Nursing Information and Data Set Evaluation Center
NIS nursing information system
NIST National Institute of Standards and Technology
NLP natural language processing
NLS national language support
NMDS Nursing Minimum Data Set
NMMDS Nursing Management Minimum Data Set
NNDSS National Notifiable Diseases Surveillance System
NOC nursing outcome classification
NPC nonplayer character
NPI national provider identifier
NSSP National Syndromic Surveillance Program
OASIS Outcomes and Assessment Information Set

OCR Office for Civil Rights
OLAP online analytic processing
ONC Office of the National Coordinator for Health Information Technology
OOSD object-oriented systems
OS operating system
OSI open systems interconnection
OSS open source software
OWL web ontology language
PaaS platform as a service
PACS picture archiving and communication system
PADS planned accelerated discharge protocols
PB petabyte
PBL problem-based learning
PC personal computer
PCA patient-controlled analgesia
PCI peripheral component interconnection
PCIS patient care information system
PDA personal data assistant; personal digital assistant
PEDA prebrief, enactment, debrief, and assessment
PERS personal emergency response system
PHI protected health information; public health informatics
PHIN Public Health Information Network
PHR personal health record
PNDS Perioperative Nursing Data Set
POSIX Portable Operating System Interface for UNIX
PPE personal protective equipment
PPS prospective payment system
PRN Patient Room 'Next'
PROM programmable read-only memory
PrtSc or Prnt Scrn print screen key on the computer keyboard
PS/2 Personal System/2
PT/INR prothrombin time/international normalized ratio
QA quality assurance
QCDR Qualified Clinical Data Registry

QPP Quality Payment Program
QRPH quality, research, and public health
RAD rapid application development
RAM random-access memory
RATS readiness assessment tests
RCT randomized controlled trial
RDBMS relational database management system
RDF resource description framework
RFI radio-frequency identifier
RFID radio-frequency identification
RHIO regional health information organization
RIS radiology information system
RLO reusable learning object
ROM read-only memory
RSS really simple syndication
RSVP Rapid Syndromic Validation Project
RU research utilization
SaaS software as a service
SCSI Small Computer System Interface
SDLC systems development life cycle
SDO standards developing organization
SDOH social determinants of health
SDRAM synchronous dynamic random-access memory
SGML Standard Generalized Markup Language
SNOMED CT Systematic Nomenclature of Medical Clinical Terms
SOX Sarbanes-Oxley Act
SPRC Suicide Prevention Resource Center
SQL Structured Query Language
STEM science, technology, engineering, and math
TB terabyte
TCO total cost of ownership
TCP Transmission Control Protocol
TELOS technical, economic, legal, operational, and schedule
TPO treatment/payment/operations

TPS transaction processing system
UC unified communications
UI user interface
URL uniform resource locator
USB universal serial bus
UX user experience
VDI virtual desktop infrastructure or virtual desktop interface
VNA Visiting Nurse Association
VPN virtual private network
VoIP Voice-over-Internet Protocol
VR virtual reality
W3C World Wide Web Consortium
WAN wide area network
WMC web-based medical chart
WWW World Wide Web
XaaS anything as a service
XML Extensible Markup Language
XR extended reality
YB yottabyte
YRBSS Youth Risk Behavior Surveillance System
ZB zettabyte

Glossary

21st Century Cures Act

See Cures Act.

3D printing

The action or process where material is deposited, joined, or solidified, based on the specifications that are stored and displayed as a digital model to build a three-dimensional object, typically layer by layer with material being combined and fused together (such as liquid molecules or powders; also known as additive manufacturing).

academic electronic medical record (AEMR)

An electronic medical record (EMR) simulation that is used in an academic setting to teach students, such as nursing students, how to use the EMR and simulate how they would document the care they provided to their assigned patients.

access

To obtain or retrieve data in order to process it.

accessibility

Ease of accessing the information and knowledge needed to deliver care or manage a health service; the extent to which a

system is usable by as many users as possible.

acquisition

The act of acquiring; to locate and hold. We acquire data and information.

active listening

A therapeutic communication technique in which the nurse employs conscious attention to what a patient is saying, reflects back feelings and phrases, and asks questions to clarify meaning.

active-matrix organic light-emitting diode (AMOLED)

Smartphone display with individual pixels being lit separately (active matrix); the next-generation super AMOLED type includes touch sensors. The active matrix provides crisp, vivid colors and darker blacks.

acuity system

The methods and processes that calculate the nursing care requirements for individual patients based on severity of illness, specialized equipment and technology needed, and intensity of nursing interventions and determine the amount of daily nursing care needed for each patient in a nursing unit.

administrative process

Used to administer the business functions of a healthcare-providing organization, such as the electronic scheduling, billing, and claims management systems, including electronic scheduling for inpatient and outpatient visits and procedures, electronic insurance eligibility validation, claims authorization

and prior approval, identification of possible research study participants, and drug recall support.

admission, discharge, and transfer (ADT) system

Provides the backbone structure for the other types of clinical and business systems; it contains the groundwork for the other types of healthcare information systems because it includes the patient's name; medical record number; visit or account number; and demographic information, such as age, sex, home address, and contact information. It is the central source for collecting this type of patient information and communicating it to the other types of healthcare information systems, including clinical and business systems.

adverse event

Any undesirable experience or outcome in a patient related to the use of a medical treatment or product.

advocate

Someone who represents another person's interests. To act in patients' best interests; to act and/or speak on patients' behalf; to make the healthcare delivery system responsive to patients' needs.

advocate/policy developer

A nurse informatics specialist who is key to developing the infrastructure of health policy. Policy development on the local, national, and international levels is an integral part of this role.

Agency for Healthcare Research and Quality (AHRQ)

An agency within the U.S. Department of Health and Human Services that supports health services research initiatives.

Agency for Toxic Substances and Disease Registry (ATSDR)

A federal agency that acts as a repository for research and data regarding hazardous materials and serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances.

agile

A software development methodology that merges iterative and incremental process models. The agile method breaks the product into small incremental builds where the teams work in short bursts, such as 2- to 4-week intervals, to accomplish their tasks. This approach lends itself well to smaller projects. Failure is considered positive if you fail fast and fail often to get to your goal. This method realizes rapid delivery of functional software to the customer.

alarm fatigue

That which results from multiple false alarms by smart technology that cause workers to ignore or respond slowly to them.

alert

Warning or additional information provided to clinicians to help with decision-making; the action of the clinician or system triggers the generation of an alert. For example, an alert could be generated if the patient's serum potassium level is high and they are on potassium chloride; the system would alert the nurse on the screen (soft copy alert) with or without audio and/or by a printed (hard copy alert) warning. Also known as a trigger.

algorithm

Step-by-step procedure for problem-solving or calculating; set of rules for problem-solving. In data mining, an algorithm defines the parameters of the data mining model; it is the method with which the data mining model is developed.

alternative

Choice between two or more options.

Alternative Payment Model (APM)

The Reauthorization Act of 2015 (MACRA) reformed Medicare payments by making changes that created a Quality Payment Program (QPP) to replace the hodgepodge system of Medicare reporting programs. The MACRA QPP has two paths—Merit-based Payment System (MIPS) or Alternative Payment Model (APM)—which will be in effect through 2021 and beyond. The APM is not just an incentive but rather a fundamental change in how health care is paid for in the United States. These models, particularly those dealing with total cost of care, have the potential to fundamentally alter the value we receive from health care.

American Library Association (ALA)

A U.S.-based organization that promotes libraries and library education internationally.

American National Standards Institute (ANSI)

An organization dedicated to promoting consensus on norms and guidelines related to the assessment of health agencies.

American Psychological Association (APA)

A scientific and professional organization that represents psychologists in the United States and that also provides a style guide for publishing and citing sources.

American Recovery and Reinvestment Act (ARRA)

An economic stimulus package enacted in February 2009 that was intended to create jobs and promote investment and consumer spending during the recession. This act has also been referred to as the Stimulus or Recovery Act. There was a push for widespread adoption of health information technology, and Title XIII of ARRA was given a subtitle, Health Information Technology for Economic and Clinical Health (HITECH) Act. Through this act, healthcare organizations can qualify for financial incentives, based on the level of meaningful use achieved; the HITECH Act specifically incentivizes health organizations and providers to become meaningful users.

analysis

Separating a whole into its component parts; examination of a concept or phenomenon and its elements and their relations.

antiprinciplism

Theory that emerged with the expansive technological changes in recent years and the tremendous rise in ethical dilemmas accompanying these changes. Opponents of principlism include those who claim that its principles do not represent a theoretical approach and those who claim that its principles are too far removed from the concrete particularities of everyday human existence because they are too conceptual, intangible, or abstract or they disregard a person's psychological factors; personality; life history; sexual orientation; or religious, ethnic, and cultural background.

antivirus software

A computer program that is designed to recognize and neutralize computer viruses, which are malicious codes that replicate over and over and eventually take over the computer's memory and interfere with its normal functioning.

application (app)

The implementation software of a computer system that allows users to complete tasks, such as word processing, presentation development, and data management.

application programming interface (API)

An interface or communication protocol between a server and a client. A computing interface to a software component or a system that defines how other components or systems can use it; the interface can be entirely customized, specific to a component of the system, or designed based on an industry standard to assure interoperability, which is key.

arithmetic logic unit (ALU)

An essential building block of the processor of a computer that digitally performs arithmetic and logical functions.

artificial intelligence (AI)

The field that deals with the conception, development, and implementation of informatics tools based on intelligent technologies. This field attempts to capture the complex processes of human thought and intelligence.

Artificial Intelligence of Things (AIoT)

The blending of artificial intelligence (AI) and the Internet of Things (IoT) infrastructure to attain more efficient and effective operations, enhance human–technology interfacing and

interactions, and improve data and information management and analytics.

art of nursing

The relationship-centered aspects of nursing care in which the focus is on communicating caring and providing emotional support and comfort to the patient.

assessment

The simulation stage in which student performance is rated or graded. Students should be provided with a detailed explanation of how they will be assessed and graded that relates to the goal; educational outcomes; and, if applicable, course or program outcomes. Detailed rubrics are recommended.

asynchronous

That which is not synchronous; not in real time or does not occur or exist at the same time, not having the same period or time frame. Learning anywhere and at any time using internet and World Wide Web software tools (e.g., course management systems, email, electronic bulletin boards, web pages) as the principal delivery mechanisms for instruction.

attribute

Quality or characteristic; field or element of an entity in a database.

audiopod

Traditional, audio-based podcast or utility to download podcasts.

augmented intelligence

The use of artificial intelligence (AI) tools to enhance but not replace decision-making with human intelligence.

augmented reality (AR)

An interactive experience within a real-world environment that enhances real-world objects using virtually simulated, or computer-generated, perceptual information. It provides stimulation for multiple senses, including olfactory, visual, auditory, haptic, and somatosensory (e.g., pressure, pain, or warmth). It comprises apps; wearable technologies, such as glasses; and software that not only interacts with users but also enhances their senses with data, information, audio, and images.

augmented-reality game (ARG)

A game in which a device, such as a smartphone, is used to overlay on the real world and bring people together physically and virtually to solve a series of challenges.

authentication

A process that serves to prove who is accessing the system.

autonomy

The right of individuals to choose for themselves.

avatar

Image on the internet that represents the user in virtual communities or other interactions on the internet; two- or three-dimensional image representing one user on the internet.

bagging

The use of voting and averaging in predictive data mining to synthesize the predictions from many models or methods or for using the same type of model on different data; it deals with the unpredictability of results when complex models are used to data mine small data sets.

baiting

Tricking a user to load an infected physical device onto their computer by leaving it in a public area, such as a copy room. The user loads the device to try to identify its owner.

bandwidth

The measurement in bits, bytes, kilobytes, megabytes, and gigabytes of the data that can be transferred from or to a computer.

barcode medication administration (BCMA)

A system using barcode technology affixed to the medication, the patient ID bracelet, and the nurse ID badge to support the five rights of medication administration.

basic input/output system (BIOS)

Binary input/output system, basic integrated operating system, or built-in operating system; a system that resides, or is embedded, on a chip that recognizes and controls a computer's devices.

Behavioral Risk Factor Surveillance System (BRFSS)

An assessment system initially designed to collect information on the movement of mentally impaired persons from state-operated facilities into community settings. The assessments have since been expanded to include other populations and are designed to determine the effectiveness of programs in meeting the healthcare needs of at-risk populations.

beneficence

Actions performed that contribute to the welfare of others.

big data

Voluminous amounts of data sets that are difficult to process using typical data processing; huge amounts of semistructured

and unstructured data that are unwieldy to manage within relational databases. Unstructured big data residing in text files represents more than 75% of an organization's data.

binary system

A system used by computers; a numeric system that uses two symbols, 0 and 1.

bioethics

The study and formulation of healthcare ethics. Bioethics takes on relevant ethical problems experienced by healthcare providers in the provision of care to individuals and groups.

bioinformatics (BI)

The application of computer science, information science, and cognitive science principles to biological systems, especially in the human genome field of study; an interdisciplinary science that applies computer and information sciences to solve biological problems.

biomedical informatics

Interdisciplinary science of acquiring, structuring, analyzing, and providing access to biomedical data, information, and knowledge to improve the detection, prevention, and treatment of disease.

biometrics

Study of processes or means to uniquely recognize individual users (humans), based on one or more intrinsic physical or behavioral attributes or characteristics. Authentication devices that recognize thumbprints, retinal patterns, or facial patterns are available. Depending on the level of security needed,

organizations will commonly use a combination of these types of authentication.

bioterrorism

The use of pathogens or other potentially harmful biological agents to sicken or kill members of a targeted population. Informatics database applications are used to track strategic indicators that may indicate an outbreak that can be attributed to bioterrorism, such as emergency room visits, disease case reports, frequency and type of lab testing ordered by physicians and/or nurse practitioners, missed work, and over-the-counter medication purchases.

bit

Unit of measurement that holds one binary digit, 0 or 1. The smallest possible chunk of data memory used in computer processing that makes up the binary system of the computer.

blended

An approach to education that combines traditional face-to-face instruction with technology-based (i.e., online) instruction. *See also* hybrid.

Blockcerts

An open infrastructure for generating, distributing, examining, and verifying blockchain-based certificates.

blockchain

A digital database containing information or a record of transactions maintained across several computers that are linked in a network that can be simultaneously used and shared within a large dispersed or decentralized, publicly accessible network; transactions are logged publicly in chronological order.

The database displays an ever-increasing list of ordered blocks; each of the blocks is time stamped and connected to the block that came before it, thereby establishing a blockchain. The technology used to craft such a database.

blog

Interactive, online weblog. Typically, a combination of what is happening on the web as well as what is happening in the blogger's or creator's life. A blog is as unique as the blogger or person creating it. Thought of as a diary and guide.

boosting

Increasing the power of models by weighting the combinations of predictions from those models to create a predicted classification; an iterative process using voting or averaging to combine the different classifiers.

borrowed theory

A theory borrowed or made use of from other disciplines. As nursing began to evolve, theories from other disciplines (e.g., psychology and sociology) were adopted to try to empirically describe, explain, or predict nursing phenomena. As nursing theories continue to be developed, nurses are now questioning whether these borrowed theories were sufficient in their relation to the nursing phenomena they were used to describe, explain, or predict.

brain

The central information-processing unit of humans. An organ that controls the central nervous system that is responsible for cognition and the interpretation and processing of and reaction to sensory input.

broadband

A wide band or range of frequencies; it is the minimum speed at which a connection to the internet will transfer information.

brushing

A technique whereby the user manually chooses specific data points, observations, or subsets of data on an interactive data display; these data can be visualized in two- or three-dimensional surfaces as scatterplots. Also known as graphical exploratory data analysis.

brute force attack

A technique whereby software creates many possible combinations of characters in an attempt to guess passwords to gain access to a network or a computer.

building block

Basic element or part of nursing informatics, such as information science, computer science, cognitive science, or nursing science.

byte

Unit of memory equal to 8 bits, or 8 informational storage units, which represent one keystroke (e.g., pressing any key on a keyboard, such as the space bar or a lowercase *a* or an uppercase *T*). The byte is considered the best unit for indicating computer memory or storage capacity.

cache memory

Memory storage used by a computer's processor to store copies of frequently used data in the main memory that is becoming smaller and faster.

call center

Registered nurse–staffed facility at which nurses typically act as case managers for callers or perform patient triage.

care ethics

An ethical approach to solving moral dilemmas encountered in health care that is based on relationships and a caring attitude toward others.

care plan

A set of guidelines that outline the course of treatment and the recommended interventions that will achieve optimal results.

caring

The nontechnical aspects of nursing interventions that communicate acceptance and concern for a patient.

caritas process

Nursing intervention that communicates loving concern for the unique humanity of every patient.

case management information system

Computer programs and information management tools that interact to support and facilitate the practice of case managers.

case scenario

A simulated real-world situation or problem using authentic constraints and parameters designed to challenge the learner to test possible outcomes.

casuist approach

An approach to ethical decision-making that grew out of the concern for more concrete methods of examining ethical dilemmas. Casuistry is a case-based ethical reasoning method that analyzes the facts of a case in a sound, logical, and ordered

manner. The facts are compared to the decisions arising out of consensus in previous paradigmatic, or model, cases.

centering

The act of taking a moment to clear one's mind of clutter and to focus one's attention exclusively on a patient prior to engaging in a therapeutic encounter.

Centers for Disease Control and Prevention (CDC)

An agency of the U.S. Department of Health and Human Services that works to protect public health and safety related to disease control and prevention.

central processing unit (CPU)

An old term for processors and microprocessors that execute computer programs, thought of as the brain controlling the functioning of the computer; the computer component that actually executes, calculates, and processes the binary computer code instigated by the operating system and other applications on the computer. It serves as the command center that directs the actions of all other components of the computer and manages both incoming and outgoing data.

central station

Multifunctional telehealthcare platform for receiving, retrieving, and displaying patients' vital signs and other information transmitted from telecommunications-ready medical devices.

certificate

A credential awarded by an education program to indicate that a learner has met course or program objectives.

certification

System for validating that a nurse possesses certain skills and knowledge or is competent to complete a task. Competence and skill level are determined by or based on an external review, assessment, examination, or education.

certified EHR technology

An electronic health record (EHR) that meets specific governmental standards for the type of record involved, either an ambulatory EHR used by office-based healthcare practitioners or an inpatient EHR used by hospitals. The specific standards to be met are set forth in federal regulations.

chief information officer (CIO)

A person involved with the information technology infrastructure of an organization. This role is sometimes called chief knowledge officer.

chief technical officer (CTO)

A person focused on organizationally based scientific and technical issues and responsible for technological research and development as part of the organization's products and services.

chief technology officer (CTO)

Another name for a chief technical officer.

Chromebook

A laptop or tablet used to perform a variety of tasks using the Google Chrome browser, with the majority of applications and data residing in the cloud instead of on the device itself.

chronic disease

A long-term disease, such as congestive heart failure, diabetes, and respiratory ailments.

civil monetary penalty (CMP)

Fine laid out by the Social Security Act, which the Secretary of Health and Human Services can assess for many types of noncompliant conduct.

classification

The technique of dividing a data set into mutually exclusive groups.

classification and regression tree (CART)

A decision tree method that is used for sorting or classifying a data set. A set of rules that can be applied to a new data set that has not been classified; the set of rules is designed to predict which records will have a specified outcome.

clinical database

A collection of related patient records stored in a computer system using software that permits a person or program to query the data to extract needed patient information.

clinical decision support (CDS)

A computer-based program designed to assist clinicians in making clinical decisions by filtering or integrating vast amounts of information and providing suggestions for clinical intervention. May also be called a clinical decision support system (CDSS).

clinical documentation improvement (CDI)

The process of reviewing medical records or clinical documentation for accuracy and completeness looking for gaps or what data and information are missing from the record in relation to the disease process, diagnostics, and coding.

clinical documentation system

Array or collection of applications and functionality; amalgamation of systems, medical equipment, and technologies working together that are committed or dedicated to collecting, storing, and manipulating healthcare data and information and providing secure access to interdisciplinary clinicians navigating the continuum of client care. Designed to collect patient data in real time and enhance care by putting data at the clinician's fingertips and enabling decision-making where it needs to occur—at the bedside. Also known as a clinical information system (CIS).

clinical informatics

Application of informatics and information technology to deliver healthcare services. It is also referred to as applied clinical informatics or operational informatics.

clinical information system (CIS)

Array or collection of applications and functionality; amalgamation of systems, medical equipment, and technologies working together that are committed or dedicated to collecting, storing, and manipulating healthcare data and information and providing secure access to interdisciplinary clinicians navigating the continuum of client care. Designed to collect patient data in real time and enhance care by putting data at the clinician's fingertips and enabling decision-making where it needs to occur—at the bedside. Also known as a clinical documentation system.

clinical practice guideline (CPG)

An informal or formal rule or guiding principle that a healthcare provider uses when determining diagnostic tests and treatment

strategies for individual patients. In the electronic health record, it is included in a variety of ways, such as prompts, pop-ups, and text messages.

clinical research informatics

The use of informatics in the discovery and management of new knowledge relating to health and disease. It includes management of information related to clinical trials and also involves informatics related to secondary research use of clinical data. Clinical research informatics and translational bioinformatics are the primary domains related to informatics activities to support translational research.

clinical transformation

The complete alteration of the clinical environment; widespread change accompanies transformational activities, and clinical transformation implies that the manner in which work is carried out and the outcomes achieved are completely different from the prior state, which is not always true in the case of simply implementing technology. Technology can be used to launch or in conjunction with a clinical transformation initiative; however, the implementation of technology alone is not justifiably a transformational ability. Therefore, this term should be used cautiously to describe redesign efforts.

cloud computing

Web browser–based logon-accessible data, software, and hardware; could link systems together and reduce costs.

cloud storage

Data storage provided by networked online servers that are typically outside of the institution whose data are being housed.

Cochrane Library

A compendium of high-quality evidence designed to inform healthcare professionals' decision-making.

cognitive informatics (CI)

Field of study made up of the disciplines of neuroscience, linguistics, artificial intelligence, and psychology. This multidisciplinary study of cognition and information sciences investigates human information-processing mechanisms and processes and their engineering applications in computing.

cognitive science

Interdisciplinary field that studies the mind, intelligence, and behavior from an information-processing perspective.

cognitive task analysis

Examination of the nature of a task by breaking it down into its component parts and identifying the performer's thought processes.

cognitive walkthrough

A technique used to evaluate a computer interface or a software program by breaking down and explaining the steps that a user will take to accomplish a task.

cognitive work analysis (CWA)

A multifaceted analytical procedure developed specifically for the analysis of complex, high-technology work domains.

collaboration

The sharing of ideas and experiences for the purposes of mutual understanding and learning.

column

Field or attribute of an entity in a database.

communication science

Area of concentration or discipline that studies human communication.

communication software

Technology programs used to transmit messages via email, telephone, paging, broadcast (e.g., MP3), and internet (e.g., instant messaging, Voice over Internet Protocol, or LISTSERV).

communication system

Collection of individual communications networks and transmission systems. In health care, it includes call light systems, wireless phones, pagers, email, instant messaging, and any other devices or networks that clinicians use to communicate with patients, families, other professionals, and internal and external resources.

community risk assessment (CRA)

A comprehensive examination of a community to identify factors that potentially affect the health of the members of that community. Often used in public health program planning.

compact disk read-only memory (CD-ROM)

Disk that can hold approximately 700 megabytes of data accessible by a computer.

compact disk-recordable (CD-R)

Compact disk that can be used once for recording.

compact disk-rewritable (CD-RW)

Compact disk that can be recorded onto many times.

compatibility

The ability to work with each other or other devices or systems—for example, software that works with a computer.

compliance

Conforming or performing in an acceptable manner; correctly following the rules.

computational biology

The action complement of bioinformatics and therefore biomedicine; it is the actual process of analyzing and interpreting data.

computer

A machine that stores and executes programs; a machine with peripheral hardware and software to carry out selected programming.

computer-aided software engineering (CASE)

Systematic application of computer software tools and techniques to facilitate engineering practice.

computer based

That which uses the computer to interact; the computer is the base tool.

computer-based information system (CBIS)

Combinations of hardware, software, and telecommunications networks that people build and use to collect, create, and distribute useful data, typically in organizational settings.

computerized provider order entry (CPOE)

An electronic process or system that automates the way that orders have traditionally been initiated for patients. It allows a healthcare provider to enter orders electronically and manage the results of those orders.

computer science

Branch of engineering (application of science) that studies the theoretical foundations of information and computation and their implementation and application in computer systems. The study of storage/memory, conversion and transformation, and transfer or transmission of information in machines (i.e., computers) through both algorithms and practical implementation problems. Algorithms are detailed, unambiguous action sequences in the design, efficiency, and application of computer systems, whereas practical implementation problems deal with the software and hardware.

conceptual framework

A framework used in research to chart feasible courses of action or to present a desired approach to a study or analysis; built from a set of concepts that are related to a proposed or existing system of methods, behaviors, functions, relationships, and objects. A relational model. A formal way of thinking or conceptualizing about a phenomenon, process, or system under study.

conferencing software

Electronic communications system or software that supports and facilitates two or more people meeting for discussion. High-end systems offer telepresence (a lifelike experience allowing people to feel as if they are present in person [it would be as though the nurse were physically there with the patient] so that people can work, learn, and play in person over the internet or have an effect at a remote location).

confidentiality

The mandate that all personal information be safeguarded by ensuring that access is limited to only those who are authorized to view that information.

connected health

A model for healthcare delivery and management that integrates technology to provide remote services and leverages healthcare resources to maximize access for consumers to engage with clinicians and facilitate the self-management of their care.

connectionism

A component of cognitive science that uses computer modeling through artificial neural networks to try to explain human intellectual abilities.

connectivity

Ability to hook up to the electronic resources necessary to meet the user's needs. The ability to use computer networks to link to people and resources. The unbiased transmission or transport of Internet Protocol packets between two end points.

consequence

An outcome or product resulting from one's choices.

Consolidated Health Informatics (CHI)

A collaborative effort to adopt health information interoperability standards, particularly health vocabulary and messaging standards, for implementation in federal government systems.

consultant

A person hired to provide expert advice, opinions, and recommendations based on their area of expertise.

context of care

The setting, services, patient, environment, and professional and social interactions surrounding the delivery of patient interventions.

continuing education (CE)

Coursework or training completed after achievement of a baccalaureate degree, often for the purpose of recertification.

copyright

A legal term used by many governments around the world that gives the inventor or designer of an original product exclusive rights to that product for a limited time; the same laws that cover physical books, artwork, and other creative material are still applicable in the digital world.

core business system

A system that enhances administrative tasks within healthcare organizations. Unlike a clinical information system, whose aim is to provide direct patient care, this system supports the management of health care within an organization. It provides the framework for reimbursement, support of best practices, quality control, and resource allocation. There are four common types of core business systems: (1) admission, discharge, and transfer (ADT); (2) financial; (3) acuity; and (4) scheduling.

courage

The strength to face difficulty.

covered entity

A healthcare provider that conducts certain transactions in electronic form (a covered healthcare provider), a healthcare clearinghouse, or a health plan that electronically transmits any health information in connection with transactions (billing and

payment for services or insurance coverage) for which the U.S. Department of Health and Human Services has adopted standards; identified in the HIPAA Administrative Simplification Regulations.

creativity software

A program that supports and facilitates innovation and creativity (an intellectual process relating to the creation or generation of new ideas, concepts, or relationships between currently existing ideas or concepts); it allows users to focus more on creating new things in today's digital age and less on the mechanics or workings of how it is created or developed.

crowdsourcing

Information generated by individuals on social media.

Cumulative Index to Nursing and Allied Health Literature (CINAHL)

A comprehensive nursing and allied health literature database.

Cures Act

The 21st Century Cures Act, known as the Cures Act, was signed into law on December 13, 2016. The Cures Act is designed to help hasten medical product development and bring innovations and advances to patients who need them sooner and more efficiently. It also contains provisions related to electronic health information (EHI). The Office of the National Coordinator for Health Information Technology (ONC) is responsible for implementing key provisions of the 21st Century Cures Act focused on advanced interoperability and the access, exchange, and use of EHI as well as information blocking.

cyborg

The shortened term for a *cyb*ernetic *org*anism. It has both biological and technological parts that are electronic, mechanical, or robotic.

data

Raw facts that lack meaning.

database

A collection of related records stored in a computer system using software that permits a person or program to query the data to extract needed information; it may consist of one or more related data files or tables.

database management system (DBMS)

Software programs and the hardware used to create and manage data.

data dictionary

Software that contains a listing of tables and their details, including field names, validation settings, and data types.

data file

A collection of related records.

data gatherer

One involved in the direct procurement of raw facts (data).

data loss prevention (DLP)

A strategy or approach for making sure that end users do not send sensitive or critical information outside the institution's network. The term also refers to software products that help the network manager or administrator control what data end users can transfer.

data mart

Collection of data focusing on a specific topic or organizational unit or department created to facilitate management personnel making strategic business decisions. Could be as small as one database or larger, such as a compilation of databases; generally smaller than a data warehouse.

data mining

A process of utilizing software to sort through data to discover patterns and ascertain or establish relationships. This process may help to discover previously unidentified relationships among the data in a database.

data set

A collection of interrelated data.

data warehouse (DW)

An extremely large database, or repository, that stores all of an organization's or institution's data and makes this data available for data mining. A combination of an institution's many different databases that provides management personnel flexible access to the data.

debrief

The simulation stage comprising a student-centered discussion during which the participants and observers reflect on performance during the scenario and make recommendations for future practice.

decision-making

Output of cognition; outcome of our intellectual processing.

decision support

Recommendations for interventions based on computerized care protocols. The decision-

support recommendations may include such items as additional screenings, medication interactions, or drug and dosage monitoring.

decision-support/outcomes manager

The person charged with reviewing the effects of interventions suggested by the computerized decision-support system.

decision tree

A set of decisions represented in a tree-shaped pattern; the decisions produce the rules for the classification of a data set.

deep learning

A subset of machine learning using a specialized algorithm known as an artificial neural network. Deep learning algorithms are able to explore many layers of a neural network simultaneously (e.g., in processing images for radiology) rather than the linear processing typical of less sophisticated algorithms.

desktop

A computer's interface that resembles the top of a desk, where the user keeps things they want to access quickly, such as paper clips, pens, and paper. On the computer's desktop, the user can customize the look and feel to have easy access to the programs, folders, and files on the hard drive that the individual uses the most.

desktop publishing

Using a desktop computer to generate printed documents, such as marketing materials, reports, and an organization's newsletters.

digital divide

The gap between those who have and those who do not have access to online information.

digital phenotyping

The processing of individual data collected by wearable technologies to suggest that an individual has health issues, especially issues related to individual mental health status.

digital video disk-recordable (DVD-R)

Disk on which a user can record once.

digital video disk-rewritable (DVD-RW)

Disk on which a user can record many times.

disruptive innovation

A new development that radically changes or disrupts the way a structure or industry functions. It is the introduction of a product or service into a well-known or established industry that outperforms (is more efficient and at a lower price point), thereby obtaining a competitive advantage, capturing the market share, and altering and transforming that industry.

dissemination

A thoughtful, intentional, goal-oriented communication of specific, useful information or knowledge.

distance education

Learning provided from a remote location.

distributed ledger technology (DLT)

A technological infrastructure with protocols that use separate, independent computers, also known as nodes, to simultaneously access, validate, record, share, coordinate, and synchronize

transactions in their electronic ledgers across a network that spans numerous entities or locations.

distributed network

A network that consists of shared programming and data spread across more than one computer.

Division of Health Informatics and Surveillance (DHIS)

A division of the Centers for Disease Control and Prevention (CDC) that manages two comprehensive public health surveillance systems, the National Notifiable Diseases Surveillance System (NNDSS) and the National Syndromic Surveillance Program (NSSP), and a data hub for research, the CDC Data Hub. It also develops information systems to support data collection exchange and processing.

document

Represents information that can be printed, saved, or emailed or otherwise shared or displayed.

domain name

A series of alphanumeric characters that forms part of the internet address, or URL (e.g., psu.edu denotes Pennsylvania State University's address).

double data rate synchronous dynamic random-access memory (DDR SDRAM)

A chip that allows for greater bandwidth and twice the transfers per the unit of time of the computer's internal clock; one of the transfers occurs at the start of the new unit of time, and the other transfer occurs at the end of the unit of time.

drill down

A means of viewing data warehouse information by going down to lower levels of the database to focus on information that is pertinent to the user's needs at the moment.

duty

One's feeling of being bound or obligated to carry out specific tasks or roles based on one's rank or position.

dynamic random-access memory (DRAM)

Type of RAM chip requiring less space to store the same amount of data as on a similar static RAM (SRAM) chip; however, DRAM requires more power than SRAM because DRAM needs to keep its charge by constantly refreshing.

dynamic system development method (DSDM)

An agile software development strategy based on the rapid application development model, which is iterative and used in the system development life cycle and project management.

dynamic web page shell

Web page that can be custom scripted to provide realistic case scenarios during a simulation experience.

earcon

An auditory tone that represents relationships among data elements, such as the relationship of systolic blood pressure to diastolic blood pressure.

ecological interface design (EID)

An approach to interface design that was introduced explicitly for multifaceted, complex, sociotechnical, real-time, and dynamic systems; it has been applied in many fields, including health care. This approach supports knowledge workers in

health care as they manage and adapt to change, innovation, and novelty.

Educational Resources Information Center (ERIC)

A comprehensive educational resources database. An international database of educational literature.

educator

A sage, leader, and/or guide who assists in the process or practice of learning.

edutainment

Learning while having fun; an activity in which learners are engaged and entertained while they learn; a combination of *education* and *entertainment*.

eHealth

Healthcare initiatives and practice supported by electronic or digital media. The most typical use is for patient and family education whereby information is communicated electronically.

eHealth Initiative

An initiative that was developed to address the growing need for managing health information and promoting technology as a means of improving health information exchange, health literacy, and healthcare delivery.

e-learning

Electronic learning, or learning that is facilitated by electronic means, such as computers and the internet. E-learning, online, and web-based education has caused a significant shift in student–teacher relationships in nursing education.

electronically erasable programmable read-only memory (EEPROM)

A nonvolatile storage chip used in computers and other devices to store small amounts of volatile data (e.g., calibration tables or device configuration).

electronic communication

Any exchange of information that is transmitted electronically.

electronic health information (EHI)

Refers to patient data that are stored in electronic form, which are collected and shared for healthcare delivery and public health. The primary use of EHI is for direct patient-care services, and its secondary use relates to public health objectives research, such as for treatment-related studies, licensure, and payment.

electronic health record (EHR)

Computer-based data warehouse or repository of information regarding the health status of a client, which is replacing the former paper-based medical record; it is the systematic documentation of a client's health status and health care in a secured digital format, meaning that it can be processed, stored, transmitted, and accessed by authorized interdisciplinary professionals for the purpose of supporting efficient, high-quality health care across the client's healthcare continuum. Also known as an electronic medical record (EMR).

electronic mailing list

Automatic mailing list server, such as LISTSERV, that automatically sends an email addressed to everyone who has subscribed to the list. Similar to an electronic bulletin board or a news forum.

electronic medication administration record (eMAR)

A system that uses barcoding technology to submit and fill prescriptions. Typically, handheld scanners read barcodes and transmit them to the pharmacy.

electronic protected health information (ePHI)

Any protected health information (PHI) that is used in any electronic format.

email

Electronic mail. To compose, send, receive, and store messages in electronic communication systems.

empowerment

Promotion of self-actualization; achievement of power or control over one's own life.

enactment

The simulation stage in which a student enacts an assigned role during the established time frame in a prepared simulation area.

encryption

A method of scrambling data so that readable text becomes unintelligible or incomprehensible so that only those authorized to see the text or information can understand it.

end user

Target user or consumer of software and computer technology. Software or computing applications should be designed for the end user, the person who will ultimately be using them.

engage

To capture the attention of students and motivate or energize them to actively participate in an educational activity.

enterprise integration

Electronically linking healthcare providers, health plans, government, and other interested parties to facilitate electronic exchange and use of health information among all stakeholders.

enterprise resource planning (ERP)

A process used to manage and integrate the essential parts of a business to facilitate resource planning since all of the processes needed to run the enterprise or company are contained within a single system.

entity

See covered entity.

entity relationship diagram (ERD)

Specifies the relationships among the entities in a database. Sometimes the implied relationships are apparent based on the entities' definitions; however, all relationships should be specified as to how items relate to one another. There are typically three relationships: one to one, one to many, and many to many.

entrepreneur

A person who assumes the risks of beginning an enterprise or a business and accepts responsibility for organizing and managing the organization.

enumerative approach

Nursing terminology in which words or phrases are presented in a list or a simple hierarchy; gives an explicit and exhaustive listing of all the objects that fall under the concept or term in question.

epistemology

Study of the nature and origin of knowledge; what it means to know.

ergonomics

In the United States, this term is used to describe the physical characteristics of equipment—for example, the optimal fit of a scissors to a human hand. In Europe, it is synonymous with human factors—that is, the interaction of humans with physical attributes of equipment or the interaction of humans and the arrangement of equipment in the work environment.

ethical decision-making

The process of making informed choices about ethical dilemmas based on a set of standards that differentiate right from wrong. The decision-making reflects an understanding of the principles and standards of ethical decision-making as well as the philosophical approaches to ethical decision-making. It requires a systematic framework for addressing the complex and often controversial moral questions.

ethical dilemma

A difficult choice or issue that requires the application of standards or principles to solve. Issues that challenge us ethically.

ethical, social, and legal implications (ESLI)

Consideration and understanding of the ethical, social, or legal connections or aspects of an issue that relate to a moral question of right and wrong.

ethicist

An expert in the arbitrary, ambiguous, and ungrounded judgments of other people. Ethicists know that they make the

best decision they can based on the situation and stakeholders at hand.

ethics

A process of systematically examining varying viewpoints related to moral questions of right and wrong.

eudaemonistic

Describes a system of ethical evaluation that involves consideration of which actions lead to being an excellent and happy person.

event

An occurrence that might be significant to other objects in a system or to external agents; for example, creating a laboratory request is an example of a healthcare event in a laboratory application. An event is defined as and could be a triggering event for the task or workflow; a task or workflow can have several triggering events.

evidence

Artifacts, productions, attestations, or other examples that demonstrate an individual's knowledge, skills, or valued attributes.

evidence-based practice (EBP)

Nursing practice that is informed by research-generated evidence of best practices.

exabyte (EB)

A unit of measure for computer memory equal to one quintillion bytes of computer memory.

execute

To carry out the instructions of a program or software.

expert system

A decision-support system that implements the knowledge of one or more human experts.

exploratory data analysis (EDA)

Approach that uses mainly graphical techniques to gain insight into a data set. It identifies the most important variables. Conducted during the exploratory phase, EDA provides guidance into the complexity or general nature of the various models that should be considered for implementation during pattern discovery.

extended reality (XR)

The umbrella term in which the *X* can represent any letter so that the term covers all of the forms of digitally altered realities that currently exist and other immersive technologies to be developed.

extensibility

A system design feature that allows for future expansion without the need for changing the basic infrastructure.

face-to-face

Most widely used teaching method among nurse educators where the teacher and learners meet together in one location at the same time.

failure modes and effects analysis (FMEA)

A systematic evaluation of a process to determine how and why it failed to produce the desired results.

fair use

Doctrine that permits the limited use of original works without the copyright holder's permission—for example, quoting or

citing an author in a scholarly manuscript.

fantasy

The activity of imagining things; hypothetical fiction set in an imaginary world or universe.

far-field communication

A region of the electromagnetic field around an object that extends beyond the near-field communication (NFC) region.

Federal Health Information Exchange (FHIE)

A federal information technology healthcare initiative that enables the secure electronic one-way exchange of patient medical information from the Department of Defense's legacy health information system, the Composite Health Care System, for all separated service members to VISTA, the Veterans Health Information Systems and Technology Architecture. The point of care in veterans' affairs.

feedback

Input in the form of opinions about or reactions to something, such as shared knowledge. In an information system, feedback refers to information from the system that is used to make modifications in the input, processing action, or output.

fidelity

The extent to which a simulation mimics the processes of a real environment; in the context of ethics, the right to what has been promised.

field

A column, or attribute, of an entity in a database.

field study

A study in which end users evaluate a prototype in the actual work setting prior to its general release. Also called a field test, an alpha test, or a beta test.

financial system

A system used to manage the expenses and revenues accrued while providing health care. The finance, auditing, and accounting departments within an organization most commonly use a financial system. This system determines the direction for maintenance and growth for a given facility. A financial system often interfaces to share information with materials management, staffing, and billing systems to balance the financial effect of these resources within an organization. A financial system reports the fiscal outcomes so that they can be tracked against the organizational goals of an institution. This system is one of the major decision-
making factors as healthcare institutions prepare their fiscal budgets. It often plays a pivotal role in determining the strategic direction for an organization.

firewall

A tool commonly used by organizations to protect their corporate networks when they are connected to the internet. A firewall can be hardware or software or a combination of the two. It examines all incoming messages or traffic to the network. The firewall can be set up to allow only messages from known senders into the corporate network; it can also be set up to look at outgoing information from the corporate network.

firmware

Hardware and software programs or data written onto read-only memory (ROM), programmable read-only memory (PROM), and erasable programmable read-only memory (EPROM).

flash drive

Small, removable storage device.

flash memory

Special type of electronically erasable programmable read-only memory (EEPROM) that can be erased and reprogrammed in blocks instead of one byte at a time. Many modern personal computers have their basic input/output system (BIOS) stored on a flash memory chip so that it can easily be updated if necessary.

Foundation of Knowledge model

A model that proposes that humans are organic information systems who constantly acquire, process, generate, and disseminate information or knowledge in both their professional and their personal lives. The organizing framework of this text.

free/libre open source software (FLOSS)

A designation that refers to freedom and not cost, offering the following freedoms: to be able to run the program, to study the source code, to be able to change the program in source code form, and to be able to distribute modified versions of the program.

free/open source software (F/OSS or FOSS)

A designation that is ambiguous since it fails to clearly explain that the word *free* in its title refers to freedom. It offers the following freedoms: to be able to run the program, to study the source code, to be able to change the program in source code

form, and to be able to distribute modified versions of the program.

game

A structured activity undertaken for enjoyment.

game mechanics

The rules, instructions, directions, and constructs that players interact with while playing the game. It is imperative that the rules be clearly stated in the instructions or directions so that the players know what is expected of them, and the game itself has rules that it, too, must obey. The mechanics determine how the players interact with the rules, and the game responds to the players' moves or behaviors within the game, thus connecting the players' actions to the purpose of the game.

gameplay

How players interact with, or play, a game.

Generation Z (Gen Z)

The generation of Americans born between 1997 and 2012 who are considered digital natives since they were born into an innovative technology world with ubiquitous social media and immediately accessible data and information.

gigabyte (GB)

A unit of measure used to express bytes of data storage and capability in computer systems; 1 GB equals 1,000 megabytes.

gigahertz (GHz)

A unit of measure used to express speed and power of some components, such as the microprocessor; 1 GHz equals 1,000 megahertz.

Glass

A wearable computer from Google that can take pictures, play video, and display text messages without anyone else knowing. Currently, it costs approximately $1,500.

good

Favorable outcome in ethics.

Government Accountability Office (GAO)

The highest audit institution of the federal government that provides auditing, evaluation, and investigative services for the U.S. Congress.

Graphical user interface (GUI [pronounced "gooey"])

Software that provides a user-friendly desktop metaphor interface that is made up of the input and output devices as well as icons that represent files, programs, actions, and processes.

graphics card

A board that plugs into a personal computer to give it display capabilities.

gray gap

A term used to reflect the age disparities in computer connectivity; there are fewer persons older than age 65 who use computer technology than members of younger age groups.

gulf of evaluation

The gap between knowing one's intention (goal) and knowing the effects of one's actions.

gulf of execution

The gap between knowing what one wants to have happen (the goal) and knowing what to do to bring it about (the means to achieve the goal).

hacker

Computer-savvy individual most commonly thought of as a malicious person who hacks, or breaks through, security to steal or alter data and information; can also be any member of a group of computer aficionados who band together in clubs and organizations or who use their skills as a hobby.

handheld device

A computer that is small enough to be used while holding in one's hand or easily carried in a pocket; synonymous with a personal digital assistant (PDA).

haptics

The science of applying tactile sensation or touch to human–computer interactions, which allows users to use special input/output devices, such as joysticks, data gloves, and sensors, to feel and manipulate a virtual three-dimensional object's attributes of texture, shape, surface, temperature, and/or weight.

hard disk

Magnetic disk that stores electronic data.

hard drive

Permanent data storage area that holds the data, information, documents, and programs saved on the computer, even when the computer is off. The actual physical body of the computer and its components.

hardware

Physical or tangible parts of the computer. Computer parts that one can touch and are involved in the performance or function of the computer, such as the keyboard and monitor.

harm

Physical or mental injury or damage. Unfavorable outcome in ethics.

head-mounted display (HMD)

A display device worn on the head with optics placed in front of the eye/eyes; used in virtual reality scenarios and for gaming.

healthcare-associated infection (HAI)

An infection that patients acquire while being treated in a healthcare facility.

health disparity

A health status difference between different groups of people, especially minorities and nonminorities; the gaps between the health status of minorities and nonminorities in the United States are ongoing even with the advances in technology and healthcare practices.

health information

Healthcare providers collect information to identify a patient and formulate a plan of care; this information consists of demographic information, diagnostic tests, insurance information, and any other data and information necessary that are collected about a patient.

health information exchange (HIE)

Organization that prepares and organizes people and resources to manage healthcare information electronically across organizations within a community or region.

health information technology (HIT)

Hardware, software, integrated technologies or related licenses, intellectual property, upgrades, or packaged solutions sold as services that are designed for or support the use by healthcare

entities or patients for the electronic creation, maintenance, access, or exchange of health information.

Health Information Technology for Economic and Clinical Health (HITECH) Act

Title XIII of the American Recovery and Reinvestment Act, which was enacted in February 2009. Under this act, healthcare organizations can qualify for financial incentives based on the level of meaningful use achieved; the HITECH Act specifically incentivizes health organizations and providers to become meaningful users.

Health Insurance Portability and Accountability Act (HIPAA)

Law signed by President Bill Clinton in 1996 addressing the need for standards to regulate and safeguard health information and making provisions for health insurance coverage for employed persons who change jobs.

Health Level Seven International (HL7)

An accredited standards-developing organization that is committed to developing standard terminologies for information technology that support interoperability of healthcare information management systems.

health literacy

The acquisition of knowledge that promotes the ability to understand and manage one's health.

health management information system (HMIS)

An information system that is specially intended to support and help with the planning, resource allocation, and management of health programming to make health care more effective and

efficient; an information system that plans and manages health programs rather than the actual delivery of health care.

Health New England

An example of an implementation model for building regional health information organizations that are functional, sustainable, and growing while reducing administrative costs.

heuristic evaluation

An evaluation in which a small number of evaluators (often experts in relevant fields, such as human factors or cognitive engineering) evaluate the degree to which an interface design complies with recognized usability principles (the heuristics).

high-hazard drug

A drug known to cause significant adverse side effects when administered inappropriately; a drug subject to frequent administration errors.

hologram

A physical structure that diffracts light into a three-dimensional image projection that can be seen without the use of a specialized camera, headset, or glasses.

home health care

An alternative site for healthcare services that typically focuses on post–hospital discharge patient needs.

home telehealth care

Home healthcare clinical and educational services provided via telecommunications-ready tools.

HONcode

One of the two most common symbols that internet users look for to identify trusted health sites.

hospital information system (HIS)

An information system intended to manage the clinical, financial, and administrative needs of the hospital; refers to the paper-based, as well as computer-based, information processing that manages the functional aspects (i.e., administrative, financial, and clinical) of a hospital.

human–computer interaction (HCI)

How people use and interact with computers; the study of how people use computers and software applications and the ways that computers influence people.

human enhancement technology (HET)

Biomedical and other technology that augments a person using human–machine integration, such as the use of artificial limbs or other prosthetics; it can make a healthy person healthier or stronger or a smart person even smarter using human genetic engineering.

human factor

Any characteristic of a person that may influence how they interact with technology.

human factors engineering

Recognizing the limitations of human performance and developing products to overcome those limitations.

human intelligence (HI)

Human intelligence is the capacity and aptitude of humans to obtain, capture, harness, and apply knowledge and wisdom through complex and multifaceted cognitive, affective, and intellectual acts generated through motivation, innovation, creativity, and mindfulness or self-awareness.

human mental workload (MWL)

Mental processing or cognitive demands placed on a person when they are interacting with technology.

human–technology interaction (HTI)

How users interact with technology. The study of that interaction.

human–technology interface

The hardware and software through which the user interacts with any technology (e.g., computers, patient monitors, or telephones).

hybrid

A descriptor for individual courses in which instruction is delivered using multiple formats, such as online, face-to-face, print based, or audio- or videoconferencing.

hypertext

Clickable words that allow users to access another document at a remote location.

immersive experience

A 3D environment that engages you and makes you suspend reality because it feels like you are there, surrounded by the environment.

implementation science

Studies that focus specifically on implementation processes to identify barriers to the implementation of new practices based on evidence.

Indiana Health Information Exchange (IHIE)

A collaborative effort among institutions in Indiana to provide high-quality patient care and enhance the safety and efficiency

of health care.

informatics innovator

One who makes enhancements or improvements and creative, novel, and inventive solutions in the informatics specialty.

informatics nurse specialist (INS)

A registered nurse with graduate-level education in the field of informatics or a related field who is considered a specialist in the field of nursing informatics.

information

Data that are interpreted, organized, or structured. Data processed using knowledge or data made functional through the application of knowledge.

Information Age

Period at the end of the 20th century, when information was easily accessible using computers, networks, and the internet.

information literacy

Recognizing when information is needed and having the ability to locate, evaluate, and effectively use the needed information. An intellectual framework for finding, understanding, evaluating, and using information.

information science

The science of information, studying the application and usage of information and knowledge in organizations and the interfacing or interaction between people, organizations, and information systems. An extensive, interdisciplinary science that integrates features from cognitive science, communication science, computer science, library science, and social science.

information system (IS)

The manual and/or automated components of a system of users or people, recorded data, and actions used to process the data into information for a user, a group of users, or an organization.

information technology (IT)

Use of hardware, software, services, and supporting infrastructure to manage and deliver information using voice, data, and video, or the use of technology from computing, electronics, and telecommunications to process and distribute information in digital and other forms; anything related to computing technology, such as networking, hardware, software, the internet, or the people who work with these technologies. Many hospitals have IT departments for managing the computers, networks, and other technical areas of the healthcare industry.

information user

The person who accesses and makes use of information made available to them.

infrastructure as a service (IaaS)

Cloud-based services that provide a rentable backbone to companies to provide the scalable, on-demand infrastructure they need to support their dynamic workloads; users pay for only what they use, and they do not have to invest in hardware, including networks, storage, and data center space.

in-plane switching liquid-crystal display (IPS LCD)

Smartphone display using polarized light that passes through a color filter, with all the pixels backlit. The liquid crystals control the brightness and which pixels are on or off. The active matrix provides crisp, vivid colors and darker blacks.

input

Data and information entered into a computer system.

instant message (IM)

A form of real-time communication between two or more people based on typed text that is conveyed via computers that are connected over a network.

integration

Assimilating or combining to make whole; in computer terminology, the process through which different technologies—software and hardware components—are synchronized and combined to make a functional and structural system.

integrity

Quality and accuracy. Employees need to have confidence that the information they are provided is true. To accomplish this, organizations need clear policies to clarify how data are actually input, determine who has the authorization to change such data, and track how and when data are changed.

intelligence

Mental ability to think logically, reason, prepare, ideate, assess alternative solutions to problems, problem solve by choosing a proposed solution, think abstractly, comprehend and grasp ideas, understand and use language, and learn.

Intelligence of Things (IoT)

Consists of intelligent or smart devices and sensors that can communicate, interact with each other, and take actions based on information collected from various things or devices.

interaction

Interfacing with users commonly using tasks or notifications.

interactive technology

A technology that promotes or supports user communication with other persons (e.g., email) or that depends on a user's response (e.g., games).

interdisciplinary collaboration

A cooperative relationship among actively engaged professionals whereby healthcare decision-making is shared effectively to combine their collective knowledge and skills to provide care.

interface

A mechanism or system used by separate things to interact. For example, if one wants to change a CD in a CD player, one could use a remote; the human user is not related to the CD player but can interact with it using the remote control. Therefore, the remote control becomes the interface that enables that person to tell the CD player which CD to play.

International Classification of Nursing Practice (ICNP)

An agreed-upon designated set of terms that are used to record nursing care globally, including observations and interventions made by the nurse. This framework provides a means to share and compare nursing care across practice settings.

International Organization for Standardization (ISO)

An international network supporting collaboration among the standards-developing agencies of numerous countries for the development of consistent standards in a multitude of industries to support a global economy. ISO is best known in the technology industries for the ISO 9000 standards. *See* International Standards Organization.

Internet2

A nonprofit consortium that develops and deploys advanced network applications and technologies for education and high-speed data transfer purposes. Led by 212 universities, it is also known as University Corporation for Advanced Internet Development.

internet browser

Software used to locate and display web pages. Also known as a web browser or just a browser.

Internet of Everything (IoE)

The connections among people, data, processes, and electronic devices.

Internet of Things (IoT)

Electronic devices that connect with each other to provide real-time data and interpretation of data without human intervention.

interoperability

Ability of various systems and organizations to work together to exchange information.

interprofessional collaboration

When two or more professionals from different disciplines work jointly together, such as when nurses and physicians collaborate to formulate and evaluate a plan of care for a patient.

interprofessional team

A collection of professionals (e.g., physicians, nurses, pharmacists, physical therapists, and nutritionists) who work together to deliver patient care and improve outcomes.

intrusion detection device

Both hardware and software that allow an organization to monitor who is using its network and which files that user has accessed.

intrusion detection system

Method of security that uses both hardware and software detection devices as a system that can be set up to monitor a single computer or an entire network. Corporations must diligently monitor for unauthorized access of their networks.

intuition

A way of acquiring knowledge that cannot be obtained by inference, deduction, observation, reason, analysis, or experience.

Iowa model

A model that facilitates the translation of research evidence into clinical practice. Also known as the Iowa model of evidence-based practice.

iPod

The name given to a family of portable MP3 players from Apple.

iteration

Replication and refinement of a method until it meets a goal or provides the desired result; each repetition is referred to as an iteration.

jump drive

Small, removable storage device.

just culture

An atmosphere of trust. In a just culture, everyone understands what is acceptable and unacceptable behavior and is urged and rewarded for supplying vital safety-related information.

justice

Fairness. Treatment of everyone in the same way.

keyboard

Set of keys resembling an actual typewriter that permits the user to input data into a computer.

key field

Within each database record, one of the fields identified as the primary key. It contains a code, name, number, or other bit of information that acts as a unique identifier for that record. In a healthcare system, for example, a patient is assigned a patient number, or ID, that is unique for that patient.

kinesthesia

See proprioception

knowledge

The awareness and understanding of a set of information and ways that information can be made useful to support a specific task or arrive at a decision; abounds with others' thoughts and information. Information that is synthesized so that relationships are identified and formalized. Understanding that comes through a process of interaction or experience with the world around us. Information that has judgment applied to it or meaning extracted from it. Processed information that helps to clarify or explain some portion of our environment or world that we can use as a basis for action or upon which we can act. Internal process of thinking or cognition. External process of testing, senses, observation, and interacting.

knowledge acquisition

The act of getting knowledge.

knowledge builder

A person who examines, interprets, and compares clinical data and trends with an eye toward improving clinical practice based on the available evidence.

knowledge dissemination

Distribution and sharing of knowledge.

knowledge domain process (KDP) model

A model that represents knowledge construction and dissemination in an organization.

knowledge exchange

The product of collaboration when sharing an understanding of information promotes learning to make better decisions in the future.

knowledge generation

The creation of new knowledge by changing and evolving knowledge based on one's experience, education, and input from others.

knowledge management system (KMS)

Repository of information that contains the latest collective expertise based on experience and research. The knowledge is typically stored in a computerized system that promotes easy access for use.

knowledge network

A digital collection that provides high-quality knowledge support to its users.

knowledge processing

The process of gathering, perceiving, analyzing, synthesizing, storing, manipulating, conveying, and transmitting knowledge.

knowledge user

An individual or a group that benefits from valuable, viable knowledge.

knowledge worker

A person who works with information and generates information and knowledge as a product.

laboratory information system

A system that reports on blood, body fluid, and tissue samples along with biological specimens that are collected at the bedside and received in a central laboratory. This system provides clinicians with reference ranges for tests indicating high, low, or normal values so that they can make care decisions. Often, the laboratory system provides result information directing clinicians toward the next course of action within a treatment regimen.

laptop

Portable, battery-powered computer that the user can take with them. Also known as a notebook.

latex-based simulation

A simulation using mannequins or other training devices made of latex.

Lean

A managerial team-based approach to enhance performance and remove waste and defects in workflow processes.

learning management system (LMS)

A software application that provides institutions with a framework for all aspects of the learning process that generally use AI and other smart technologies.

levels of prevention

The three levels of prevention are primary, secondary, and tertiary. Primary is preventing pathophysiologic changes. Secondary is early detection and intervention. Tertiary is chronic with the aim of minimizing the deficits and maximizing the potential.

liberty

The independence from controlling influences.

library science

An interdisciplinary science that integrates law, applied science, and the humanities to study issues and topics related to libraries (i.e., collection, organization, preservation, archiving, and dissemination of information resources).

local area network (LAN)

Organizationally based network that is joined together locally.

logic

A system of thinking that uses principles of inference and reasoned ideas to govern action.

machine learning (ML)

A subset of artificial intelligence that permits computers to learn either inductively or deductively. Inductive machine learning is the process of reasoning and making generalizations or extracting patterns and rules from huge data sets—that is, reasoning from a large number of examples to a general rule. Deductive machine learning moves from premises that are assumed true to conclusions that must be true if the premises are true.

main memory

A computer's internal memory.

malicious code

Software that includes spyware, viruses, worms, and Trojan horses.

malicious insider

A person inside or an employee of an organization who sabotages or adds malicious code or hacks into systems to cause damage or steal data and information.

malware

Malicious software; an evil, malicious program that infects a device and is intended to steal information or take control of, irritate, damage, or destroy data, information, or the device.

managed care information system (MCIS)

An information system that crosses organizational boundaries so that data can be obtained at any and all of the patient areas; this system makes it possible for nurses and physicians to make clinical decisions while being mindful of their financial ramifications.

mapping

How environmental facts (e.g., the order of light switches or variables in a physiological monitoring display) are accurately depicted by the information presentation.

mask

A method that a proxy server uses to protect the identity of a corporation's employees while they are surfing the World Wide Web. The proxy server keeps track of which employees are using which masks and directs the traffic appropriately.

Massachusetts Health Data Consortium (MHDC)

A consortium of regional healthcare organizations that collects data, publishes comparative information, supports and promotes electronic standards, educates, and researches.

massive multiplayer online role-playing game (MMORPG)

A game using the internet to provide a shared, simultaneous experience for dozens or even hundreds of players.

massive open online course (MOOC)

A virtual or an online course with unlimited participation and open access via the web. Typically, a MOOC provides interactive opportunities using social media or other means to support community interactions among learners and teachers.

meaningful use (MU)

The American Recovery and Reinvestment Act of 2009 specifies three components of meaningful use: (1) the use of a certified electronic health record (EHR) in a meaningful manner, such as e-prescribing; (2) the use of certified EHR technology for electronic exchange of health information to improve quality of health care; and (3) the use of certified EHR technology to submit clinical quality and other measures. The criteria for meaningful use was staged in three steps. Stage 1 (2011–2012) set the baseline for electronic data capture and information sharing. Stage 2 (2013) and Stage 3 (2015) continued to expand on this baseline and were developed through future rulemaking.

medical home model

A model to provide complete, comprehensive, and uninterrupted health care that is led by the healthcare provider. This model uses a team-based approach to healthcare delivery to achieve

optimal health outcomes; it is also known as the patient-centered medical home.

medical informatics

A specialty that integrates medical science, computer science, cognitive science, and information science to manage and communicate data, information, knowledge, and wisdom in medical practice.

Medicare Access and CHIP Reauthorization Act of 2015 (MACRA)

An act that reformed Medicare payments by making changes that created a Quality Payment Program (QPP) to replace the hodgepodge system of Medicare reporting programs.

medication management device

A telecommunications-
ready medication device used to remind or otherwise alert patients to medication compliance needs.

MEDLINE

A database that contains more than 22 million records, maintained and produced by the National Library of Medicine.

megabyte (MB)

A unit of measure used to express the amount of data storage and capability in computer systems; 1 MB equals 1,000 kilobytes.

memory

Data stored in digital format; generally refers to random-access memory (RAM).

Merit-based Incentive Payment System (MIPS)

The Reauthorization Act of 2015 (MACRA) reformed Medicare payments by making changes that created a Quality Payment Program (QPP) to replace the hodgepodge system of Medicare reporting programs. The MACRA QPP has two paths—Merit-based Incentive Payment System (MIPS) or Alternative Payment Model (APM)—which will be in effect through 2021 and beyond. As a consolidation and refinement of various incentive programs, MIPS is an important program, but it neither aspires to nor will drive change in the value of health care at anywhere near the levels of change that the retirement of the baby boomer generation will force upon Medicare and society.

meta-analysis

A form of systematic review that uses statistical methods to combine the results of several research studies.

meta-learning

Learning that combines the predictions from several data mining models with the goal of synthesizing these predicted classifications to generate a final best predicted classification, also known as stacking.

metaverse

The evolution of the latest frontier of the internet that is continuously accessible and available, trisecting artificial intelligence (AI), the realities (mixed reality [MR]: augmented reality [AR] through virtual reality [VR]), and our psychosocioeconomic digital and physical presence. The metaverse promises hyperconnected blurred or blended reality experienced through seamless immersive interactive exchanges on the devices we use, from laptops to tablets to smartphones.

metrics

Measurements or sets of measurements to quantify performance; they provide understanding about the performance of a process or function. Typically, within clinical technology projects, one identifies and collects specific metrics about the performance of the technology or metrics that capture the level of participation or adoption. Equally important is the need for process performance metrics. Process metrics are collected at the initial stage of a project or problem identification. Current-state metrics are then benchmarked against internal indicators. When there are no internal indicators to benchmark against, a suitable course of action is to benchmark against an external source, such as a similar business practice within a different industry.

microblog

A social media site where the users make frequent, short posts; a type of blog where users post small texts or pieces of digital content, such as pictures, images, video, or audio on the internet. These posts are called microposts, and they are immediately available to view.

microblogging

Refers to making frequent, short posts to a microblog.

micropost

A brief post to a personal blog on a microblogging social media site, such as Twitter; could be a series of brief posts.

microprocessor

A chip that integrates the processor onto one circuit, incorporating the functions of the computer's central processing

unit. Microprocessors continue to evolve in terms of their processing capacity.

milestone

Predetermined planned occurrence that indicates the completion or achievement of a deliverable.

millions of instructions per second (MIPS)

The number of machine instructions that a computer can execute in one second—in this case, millions per second.

mind

The brain's conscious processing; encompasses thought processes, memory, imagination and creativity, emotions, perceptions, and inner drive or will.

mixed reality (MR)

The blending of the physical world with the digital world to create new environments and visualizations along the continuum from augmented reality (AR) to virtual reality (VR).

mobile

Refers to our ability to move freely without compromising our professional and personal connectivity and relates to laptops, smartphones, and tablets (among others) that support our ability to work, play, and socialize from anywhere.

mobile app

Software program that operates or runs on smartphones and other mobile communication devices. It can also be an accessory that attaches or connects to a smartphone or other mobile communication device or a combination of accessory and software.

mobile computing

A technology that allows human–computer interaction wherever a person is, which transports the capability of transmitting data, voice, and video with them.

mobile device

A handheld computer, such as a smartphone or tablet.

mobile health (mHealth)

Health-related uses of mobile technology, including mobile phones (and increasingly, internet-enabled, wireless-connected smartphones), personal digital assistants, tablet computers and subnotebook microcomputers, remote diagnostic and monitoring devices, and global positioning system (GPS)/geographic information system (GIS) mapping equipment; set of apps, devices, and connections supported by mobile devices for medical and public health use.

modeling

Refers to creating a representation or model, such as making 3D models.

modem (modulator–demodulator)

Hardware that allows a user to send and receive information over the phone or cable lines—for example, with a computer. It enables internet connectivity via a telephone line or cable connection through network adaptors situated within the computer apparatus.

monitor

Computer display that allows the user to view text and graphic images.

moral

A social convention about right and wrong human conduct that is socially constructed and tacitly agreed upon as good or right.

moral dilemma

A situation for which there is no clear evidence that one of several alternatives is morally right or wrong.

moral right

An ethical privilege.

MoSCoW

Must have, should have, could have, and would have; an approach in which a team works with stakeholders to develop a prioritized requirements list and a development plan.

motherboard

A key foundational computer component. All other components are connected to it in some way (by local sockets or cables or attached directly to it). The essential structures of the motherboard include the major chipset, super input/output (I/O) chip, basic input/output system (BIOS), read-only memory (ROM), bus communications pathways, and a variety of sockets that allow components to plug into it.

mouse

A small device that one can roll along or scroll to control the movement of the pointer or cursor on a display and click to search for and/or execute features.

MP3 aggregator

A program that can facilitate the process of finding, subscribing to, and downloading podcasts. A commonly known aggregator is Apple's iTunes, which is a free program available as a download from apple.com. Using a program such as iTunes

gives the user the ability to search for podcasts based on many criteria, including category, author, or title. iTunes provides access to audio downloads, which may be either songs or podcasts.

MP4

A digital multimedia file format capable of storing video and audio.

MPEG-1 Audio Layer-3 (MP3)

Digital or electronic audio programming format.

multidimensional database

A database that combines data from numerous data sources and is optimized for online analytical processing applications; it uses multidimensional structures to organize the data, and each data attribute is considered as a separate dimension.

multimedia

A computer-based technology that incorporates traditional forms of communication to create a seamless and interactive learning environment.

Multimedia Educational Resource for Learning and Online Teaching (MERLOT)

A web-based open resource that provides access to curated online learning and support materials and content creation tools led by an international community of educators, learners, and researchers.

multiuser dungeon (MUD)

A computer program, usually running over the internet, that allows multiple users to participate in virtual-reality role-playing games.

National Health and Nutrition Examination Survey (NHANES)

A survey sponsored by the Centers for Disease Control and Prevention that combines both questionnaires and physical examinations to collect data on the health and nutritional status of adults and children in the United States.

National Health Information Infrastructure (NHII)

An initiative intended to improve the effectiveness, efficiency, and overall quality of health and health care in the United States. A comprehensive knowledge-based network of interoperable systems of clinical, public health, and personal health information that would improve decision-making by making health information available when and where it is needed. The set of technology, standards, applications, systems, values, and laws that support all facets of individual health, health care, and public health. The NHII is voluntary and not a centralized database of medical records or a government regulation.

Nationwide Health Information Network (NHIN)

An agency of the U.S. Department of Health and Human Services charged with the development of a safe, secure, interoperable health information infrastructure. This network is sponsored by the Office of the National Coordinator for Health Information Technology (ONC), which began NHIN development in 2004, and consists of a set of standards, policies, and services that enable secure health information exchange (HIE) over the internet.

natural language processing (NLP)

A discipline of computer science concerning the relationship between computers and human language that requires machine learning skills from the disciplines of artificial intelligence and computational linguistics. It is the process of using computer algorithms to identify key elements in everyday language and extract meaning from unstructured spoken or written input. The computer is able to understand, analyze, manipulate, and generate natural language.

near-field communication (NFC)

A short-range region of the electromagnetic field around an object that transitions to far field, which has an extended range; a wireless and contactless communication technology that makes a device even smarter because it streamlines information transmissions and is the ultimate in connectivity. It allows the user to wave the smartphone over an NFC- compatible device to send information without having to touch the devices together or complete multiple steps to set up the connection.

near-field communication–enabled medication administration (NFCMA)

A system that takes advantage of a mobile device equipped with a reader for near-field communication (NFC), a wireless communication protocol allowing a secure exchange of small amounts of data by proximity or touch.

Near Field Communication Interface and Protocol (NFCIP-1)

A standard targeted at secure means of making two devices communicate. The NFCIP-1 wireless devices' interfaces configure them to link up where you can bring them together or make them touch in a peer-to-peer network. Using near-field

communication (NFC), once the configuration data are exchanged, the devices can then establish and continue communicating for longer-range and quicker protocols such as Wi-Fi or Bluetooth.

negligence

A departure from the standard of due care (i.e., prudent and reasonable care) toward others, including intentionally posing risks that are unreasonable as well as unintentionally but carelessly imposing risks.

negligent insider

A well-meaning but careless employee who unintentionally exposes a network to security vulnerabilities by ignoring or forgetting about proper security procedures.

Net Generation

Students accustomed to surfing the web and interacting online.

network

Computers linked together in a small area scope (i.e., locally and/or organizationally) using a local area network; in a wider area scope (e.g., a city or district) using a metropolitan area network; or over an even greater distance (e.g., a whole country or continent or the internet in general) using a wide area network.

network accessibility

The ability of the network to be accessed by the right user to obtain what that person needs when they need it.

network availability

The state in which network information is accessible when needed.

network security

The specific precautions taken to ensure that the integrity of a network is safe from unauthorized entry and that the data and information stored on the network are accessible only by authorized users.

neural network

A nonlinear predictive model. Such a model learns by training and resembling the structure of a biological neural network. A neural network models the neural behavior of the human brain and is a way to bridge the gap between computers and humans.

neuroscience

The study of the nervous system.

never event

An occurrence that should never happen, such as wrong-site surgeries and retained surgical objects. Although rare, over 4,000 patients per year have the wrong site operated on or retained surgical objects.

Next Generation Internet (NGI)

A government project to develop new and faster technology to enhance research and communication.

Nicomachean ethics

An approach to ethical thinking based on the work of Aristotle.

nonmaleficence

Doing no harm.

nonplayer character (NPC)

An individual in a simulation, virtual world, or game that is controlled by the program, not another person.

nursing informatics (NI)

Traditional definition: A specialty that integrates nursing science, computer science, and information science to manage and communicate data, information, knowledge, and wisdom in nursing practice. Our definition: The synthesis of nursing science, information science, computer science, and cognitive science for the purpose of managing, disseminating, and enhancing healthcare data, information, knowledge, and wisdom to improve collaboration and decision-making; provide high-quality patient care; and advance the profession of nursing. NI is the specialty that integrates nursing science with multiple information management and analytical sciences to identify, define, manage, and communicate data, information, knowledge, and wisdom in nursing practice. NI supports nurses, consumers, patients, the interprofessional healthcare team, and other stakeholders in their decision-making in all roles and settings to achieve desired outcomes. This support is accomplished through the use of information structures, information processes, and information technology.

nursing informatics competencies

A set of essential skills related to informatics that are deemed appropriate for various levels of nursing practice.

nursing science

The ethical application of knowledge acquired through education, research, and practice to provide services and interventions to patients to maintain, enhance, or restore their health; to advocate for health; and to acquire, process, generate, and disseminate nursing knowledge to advance the nursing profession.

nursing theory

Concepts, propositions, and definitions that represent a methodical viewpoint and provide a framework for organizing and standardizing nursing actions.

object-oriented multiuser dungeon (MOO)

Similar to a multiuser dungeon, it is a computer program, usually running over the internet, that allows multiple users to participate in virtual reality role-playing games but with more advanced programming features.

object-oriented systems development (OOSD)

Occurs when objects (small chunks of programs) are used alone or in combination with other objects to create an application that is made up of smaller pieces or objects.

Office for Civil Rights (OCR)

Part of the U.S. Department of Health and Human Services and responsible for enforcing the Health Insurance Portability and Accountability Act (HIPAA). It provides significant information and guidance to clinicians who must comply with the Privacy and Security Rules. It has been tracking complaints and investigating violations since 2003.

Office of the National Coordinator for Health Information Technology (ONC)

An office within the U.S. Department of Health and Human Services that was established through the HITECH Act. The ONC is headed by the national coordinator, who is responsible for overseeing the development of a nationwide health information technology infrastructure that supports the use and exchange of information.

office suite

Software that is generally distributed together with a consistent user interface that is designed for knowledge workers and clerical personnel. These software packages can interact with each other to enhance productivity and ease of use.

online analytic processing (OLAP)

A fast analysis of shared data stored in a multidimensional database that allows the user to easily and selectively extract and view data from different points of view. OLAP and data mining complement each other, even though they are quite different.

online chat

A synchronous interaction with another person facilitated by an internet connection technology.

ontological approach

Theory that considers ontology development (domain analysis) and its mapping to object models (specification of infrastructure). Based on enumerating all concepts used in a domain and in providing their formal definitions according to suitable formalisms (usually logic based).

Open Access Initiative

A worldwide movement to make a library of knowledge available to anyone with internet access.

open source

Computer software for which the source code is made available for use and/or modification without charge. The developers share code in the hopes that the software will evolve as others modify and improve upon the base.

open source software (OSS)

Software that enables users to freely copy and reuse or repurpose the software by providing access to the source code; free and open use of software source code.

operating system (OS)

The most important software on any computer. It is the very first program to load on computer start-up and is fundamental for the operation of all other software and the computer's hardware.

order entry management

A program that allows a clinician to enter medication and other care orders directly into a computer, including orders for laboratory, microbiology, pathology, radiology, nursing, and medicine; supply orders; ancillary services; and consults.

order entry system

A system that automates the way that orders are initiated for patients. Clinicians place orders within this system, instead of using traditional handwritten transcription onto paper. Such a system provides major safeguards by ensuring that physician orders are legible and complete, thereby providing a level of patient safety that was historically missing with paper-based orders. It also provides decision support and automated alert functionality, which were previously unavailable with paper-based orders.

outcome

Changes, results, and/or effects from inputting and processing.

output

Changes that exit a system and can activate or modify processing.

password

A code established by the user to identify themselves when they enter the system. Most organizations today enforce a strong password policy. Strong password policies include using combinations of letters, numbers, and special characters, such as plus (+) signs and ampersands (&). Policies typically include the enforcement of changing passwords every 30 or 60 days.

patient care information system (PCIS)

Patient-centered information system focused on collecting data and disseminating information related to direct care. Several of these systems have become mainstream types of systems used in health care. The four types of systems most commonly found in healthcare organizations are (1) clinical documentation systems, (2) pharmacy information systems, (3) laboratory information systems, and (4) radiology information systems.

patient care support system

A system of components that make up each of the specialty disciplines within health care and their associated patient-care information systems. The four types of systems most commonly found in healthcare organizations are (1) clinical documentation systems, (2) pharmacy information systems, (3) laboratory information systems, and (4) radiology information systems.

patient centered

Focused on the patient rather than on the illness or healthcare professional, with the patient becoming an active participant in their own healthcare initiatives. Patients as active participants

receive services designed to meet their individual needs and preferences, under the guidance and counsel of their healthcare professionals. Data, observations, interventions, and outcomes focused on direct patient care.

patient-centered care

Care that is responsive to and cognizant of patient preferences, values, and needs.

patient engagement

Refers to the patient wanting to and being able to actively participate by cooperating and collaborating with their healthcare provider to have their unique perspective included in their own care regimen and to optimize their outcomes and their experience during their healthcare process.

patient informed consent

A document that a patient signs to agree to treatment. A document that a home healthcare patient signs to agree to receive telehealthcare services in addition to conventional home health care.

Patient Room 'Next' (PRN)

An approach to provide high-
quality healthcare to patients wherever they are; it is an agile, integrated framework to improve the quality of health care no matter where care is provided.

patient support

The total array of tools and software that can be used to provide information and assistance to help meet the healthcare needs of consumers.

perception

The process of acquiring knowledge about the environment or situation by obtaining, interpreting, selecting, and organizing sensory information from seeing, hearing, touching, tasting, and smelling. Sensory experience foundational to formulating knowledge.

peripheral biometric (medical) device

A telecommunications-
ready measurement device, such as a blood pressure cuff or blood glucose meter, that typically uses a household telephone jack to transmit patient data to a central server location.

peripheral component interconnection (PCI)

Mechanism for attaching peripheral devices to a motherboard via computer bus, expansion slots, or integrated circuits.

personal computer (PC)

Computer made for individual use or directly used by an end user.

personal emergency response system (PERS)

A signaling device that enables patients to access emergency and other care needs.

petabyte (PB)

A unit of information or computer storage equal to 1 quadrillion bytes, or 1,000 terabytes.

pharmacy information system

An information system that facilitates the ordering, managing, and dispensing of medications for a facility. It also commonly incorporates allergy and height and weight information for effective medication management; it streamlines the order entry, dispensing, verification, and authorization process for

medication administration while often interfacing with clinical documentation and an order entry system so that clinicians can order and document the administration of medications and prescriptions to patients while having the benefits of decision-support alerting and interaction checking.

phishing

An attempt to steal information by manipulating the recipient of an email or phone call to provide passwords or other private information.

picture archiving and communication system (PACS)

A system that is designed to collect, store, and distribute medical images, such as computed tomography scans, magnetic resonance images, and X-rays; it replaces traditional hard copy films with digital media that are easy to store, retrieve, and present to clinicians. This system may be a stand-alone system, separate from the main radiology system, or it can be integrated with a radiology information system and a computer information system. The benefit of a PACS is its ability to assist in diagnosis and store vital patient care support data.

platform as a service (PaaS)

Cloud computing service that provides everything needed to support the cloud application's building and delivering life cycle, which enables users to develop and launch custom web applications rapidly to the cloud.

plug and play

The ability to easily add new devices to a computer without having to manually install and reconfigure the computer to accept the device.

podcast

A digital media file or collection of related files that are distributed over the internet using syndication or a subscription feed for playback on portable media players, such as MP3 players, laptops, and personal computers; the subscription relies on RSS (really simple syndication) feeds. Online media delivery. Enhanced podcasts contain slides and pictures; vodcasts contain videos.

policy

A basic principle that guides behavior and performance and is enforced. For example, in a corporation, corporate policy would be enforced by corporate administration; the U.S. government enforces public policy.

population health management

A term adopted by healthcare management companies to express their goal of achieving optimal health outcomes at a reasonable cost. The management process involves data collection and trend analyses that are used to predict clinical outcomes in a group of people.

portability

Ability to be transported easily. For example, users can easily take handheld computers wherever they go.

portal

A tool for organizing information from web pages into simple menus on a desktop computer. Also, a multifunctional telehealthcare platform for receiving, retrieving, and displaying patients' vital signs and other information transmitted from telecommunications-ready medical devices.

portfolio

A collection of evidence used to demonstrate knowledge and skill achievement. A nursing portfolio provides the opportunity for a student to document a variety of sometimes unquantifiable skills, such as creativity, communication, and critical thinking.

power supply

A device that supplies electrical energy, or power; the device that provides the electrical energy, or power, to the computer. A battery can be a source of energy, or power.

prebrief

The simulation stage in which the student receives the simulation information: goal, educational outcomes, and related course or program outcomes. The simulation is explained and focused for students. They should know how to prepare for the activity and be told what is expected of them, provided with the background necessary to be able to fully enact their role in the activity, and given specifics about how they will be assessed. Students must also be provided with the time frame within which the simulation must be completed.

prebrief, enactment, debrief, and assessment (PEDA)

The process used to run a simulation scenario.

presence

The act of being fully there with patients; exclusively focusing on patients and their unique needs.

presentation

Act of presenting or showing; typically uses presentation software in a slide show format. The most commonly used

presentation software in the United States is Microsoft PowerPoint.

prevention informatics

Harnessing real-time social data and aggregating and representing these data in a meaningful way so that an appropriate healthcare prevention initiative can be mounted proactively.

primary key

A field within a record (also known as the key field) that contains a code, name, number, or other bit of information that acts as a unique identifier for that record. In a healthcare system, for example, a patient is assigned a patient number, or ID, that is unique for that patient.

principlism

A foundation for ethical decision-making. Principles are expansive enough to be shared by all rational individuals, regardless of their backgrounds and individual beliefs.

privacy

An important issue related to personal information about the owner of the information or about other individuals that focuses on sharing this information with others electronically and the mechanisms that restrict access to this personal information.

problem based

Typically, refers to a type of student-centered instructional strategy whereby students collaboratively solve problems and reflect on their experiences.

problem-solving

Cognitive process of critically thinking through a problem or issue to determine a course of action.

process analysis

Breaking down the work process into a sequential series of steps that can be examined and assessed to improve effectiveness and efficiency; explains how work takes place or gets done or how it can be done.

processing

Acting on something by taking it through established procedures to convert it from one form to another. Examples include the processing of information into data and the processing of a credit application to get a loan.

process map

A visual depiction of the output of a workflow analysis process.

processor

Newer term for central processing unit (CPU); the component that executes computer programs, which is thought of as the brain controlling the functioning of the computer; the computer component that actually executes, calculates, and processes the binary computer code instigated by the operating system and other applications on the computer. It serves as the command center that directs the actions of all other components of the computer and manages both incoming and outgoing data.

process owner

One of several persons who directly engage in the workflow to be analyzed and redesigned and have the ultimate responsibility for the performance of the process. These individuals can speak about the intricacy of the process, including process variations

from the normal. When constructing a team, it is important to include individuals who are able to contribute information about the exact current-state workflow and offer suggestions for future-state improvements.

product developer

One who designs, creates, and builds a product, such as a computer program, network, and/or system. One who employs productivity software to create a product.

productivity software

Programs or software that helps us compose, create, or develop. An example is the Microsoft Office suite of productivity tools, which offers word processing, spreadsheet, database, presentation, and web tools to help us complete both professional and personal tasks.

professional development

Acquisition of skills required for maintaining a specific career path or general skills offered through continuing education, including the more general skills area of personal development. It can be seen as training to keep current with changing technology and practices in a profession or as part of the concept of lifelong learning.

professional networking

Connecting with other professionals in a field with a predetermined and focused purpose as well as an identified target audience in mind.

programmable read-only memory (PROM)

Form of digital memory whereby the setting of each bit is locked on a chip by a fuse or an antifuse. PROM is used to store

programs permanently, so it is useful in applications for which the programming needs to be permanent. The device cannot be erased, so it must be replaced if changes are deemed necessary in the system.

project manager

The person responsible for the success of a project who manages the planning and enactment of the project.

proprioception

The perception or sense of the relative position of body segments in relation to other parts of the body; the awareness of the position and movement of the body or the ability of the body to sense where it is, its location, and its movements and actions; also known as kinesthesia.

protected health information (PHI)

Any and all information about a person's health that is tied to any type of personal identification.

prototype

Original mock-up or first model; original form that is studied, tested, and processed before duplication.

proxy server

Hardware security tool to help protect an organization against security breaches.

pseudo AI

Using humans to complete the tasks assigned to artificial intelligence (AI). Companies that cannot navigate the complexities of AI employ human impostors who fake AI by pretending to be the machines assigned to do the work of humans.

PsycArticles

A database that provides complete access to approximately 80 journals in behavioral science and nursing, among other fields.

psychology

The field that studies the mind and behavior.

PsycInfo

A comprehensive database in the field of education and psychology.

public health

The science of protecting the well-being of communities and the population through education, research, intervention, and prevention.

public health informatics (PHI)

An aspect of informatics focused on the promotion of health and disease prevention in populations and communities.

Public Health Information Network (PHIN)

A division of the Centers for Disease Control and Prevention that promotes semantic interoperability and secure data exchange among public health information systems.

public health intervention

An action taken to promote and secure the well-being of a population or a community.

PubMed

A free full-text searchable archive of biomedical sciences journal literature at the U.S. National Institutes of Health's National Library of Medicine (NIH/NLM).

Qualified Clinical Data Registry (QCDR)

Introduced for the Physician Quality Reporting System (PQRS) beginning in 2014, a QCDR will complete the collection and submission of PQRS quality measures data on behalf of individual eligible professionals (EPs) and PQRS group practices. As of 2016, a QCDR is a Centers for Medicare and Medicaid Services–approved entity that collects medical and/or clinical data for the purpose of patient and disease tracking to foster improvement in the quality of care provided to patients.

qualified electronic health record

An electronic record containing health-related information on an individual, which consists of the individual's demographic and clinical health information, including medical history and a list of health problems, and supports entry of physician orders. A qualified electronic health record can capture and query information relevant to healthcare quality and exchange electronic health information with and assimilate such information from other sources to provide support for clinical decision-making.

qualitative study

A type of research design that focuses on the human experience of a phenomenon using words, concepts, language, and meanings, rather than numbers, to capture the essence of the subject under study. Subjective study.

quality

A level or grade of excellence; relative merit; a distinct or essential characteristic, attribute, or property.

quality improvement (QI)

A systematic process using data metrics and outcome measures to enact a change to an organization's process or workflow with the goal of enhancing the quality of the process or the outcome.

Quality Payment Program (QPP)

This program rewards value and outcomes through the Merit-based Incentive Payment System (MIPS) and advanced alternative payment models (APMs).

quality, research, and public health (QRPH)

This health information exchange (HIE) domain was formed in 2007 to address use cases related to repurposing clinical data for secondary uses through information exchange and electronic health record (EHR) standards to allow information to be shared that is relevant to quality improvement in patient care, clinical research, and public health monitoring.

quantitative study

Research that looks at the *what*, *where*, and *when* to provide understanding of phenomena based on quantifying data and using statistical measures; depending on the research, it may ascertain cause-and-effect relationships. Objective study.

quantum bit (qubit)

Three-dimensional array of atoms in a quantum state.

quantum computing

Using a quantum computer.

query

A form of questioning. A request for information—for example, a database query.

QWERTY

Name given to the typical computer keyboard layout, derived from the six letters in the first row below the number row.

radio-frequency identification (RFID)

Uses radio waves to identify objects or people with encoded microchips.

radiology information system (RIS)

Information system designed to schedule, report, and store information as it relates to diagnostic radiology procedures. One common feature found in most radiology systems is a picture archiving and communication system (PACS). The benefit of RISs and PACSs is their ability to assist in diagnosing complex cases and storing vital patient care support data.

random-access memory (RAM)

Volatile, temporary storage system that allows a computer's processor to access program codes and data while working on a task. RAM is lost once the system is rebooted or shut off or loses power.

randomized controlled trial (RCT)

A study design that randomly assigns participants into an experimental group or a control group. As the study is conducted, the only expected difference between the control and the experimental groups in an RCT is the outcome variable being studied.

ransomware

A specific type of malware or malicious code that cripples the computer network until a ransom is paid by the organization whose network was compromised.

rapid application development (RAD)

A method using prototyping and reiteration to develop products faster and of superior quality.

rapid prototyping

A group of techniques and processes that allow for the quick development of scale models to be built and evaluated.

Rapid Syndromic Validation Project (RSVP)

A system for local healthcare professionals to report cases, such as influenza. Data are analyzed centrally, and the resulting information is shared with appropriate local authorities to try to identify outbreaks early and prevent the spread of contagious diseases.

read-only memory (ROM)

Essential permanent or semipermanent, nonvolatile memory that stores saved data and is critical in the working of the computer's operating system and other activities. ROM is primarily stored in the motherboard but may also be available through the graphics card, other expansion cards, and peripherals.

reality

Real life; the world or the state of things as they actually exist; the state of being actual or real.

really simple syndication (RSS)

A form of web feed used to publish frequently updated content in podcasts, blog entries, or news headlines. Subscribers receive update notices whenever new content is added or a site is updated. Also known as RDF site summary (RSS 1.0 and RSS 0.90) and rich site summary (RSS 0.91).

real time

Human time; occurs live, with users or learners interacting at the same time.

real-time telehealth

Live interactions between two or more clinicians or a clinician and a patient, usually performed with videoconferencing equipment.

reasoning

Way of thinking, calculating, interpreting, or introspectively rethinking or critically thinking through an issue; reflective thought to analyze or think through one's ideas and alternatives.

record

A row in a relational database that represents, for example, individual patients; also called a tuple. Groups of related fields in a database. As a verb, record means to capture audio and video using specific devices.

reflective commentary

Narrative comments that focus on why individuals think specific evidence is important, the ways in which they value what they have learned, or why they think the evidence is important for their profession.

regional health information exchange

See regional health information organization.

regional health information organization (RHIO)

A regional network of healthcare organizations and providers who exchange information related to the health of the population. The goal is to work together without duplication to provide cost-effective health care and promote community well-being.

relational database

A database that can store and retrieve data very rapidly. *Relational* refers to how the data are stored in the database and how they are organized.

relational database management system (RDBMS)

A system that manages data using the relational model. A relational database could link a patient's table to a treatment table, for example, by a common field, such as the patient ID number field.

report

Document that contains data or information, based on a query or an investigation, designed to yield customized content in relation to a situation and a user, a group of users, or an organization. Designed to inform, reports may include recommendations or suggestions based on programming and other embedded parameters.

reporting

The act of using documents or information system outputs to convey information to stakeholders.

repository

Central place where data are collected, stored, and maintained. Central location for multiple databases or files that can be distributed over a network or are directly accessible to the user. Location for files and databases so that the data can be reused, analyzed, explored, or repurposed.

researcher

A person who performs systematic inquiries of a topic to develop knowledge on that topic; a person who does research.

research utilization (RU)

The process of moving new understandings generated in research into practice.

research validity

A conclusion that can be drawn about the conduct of research based on an analysis of the research design and methods (i.e., internal validity) and the applicability of the findings to the general population (i.e., external validity).

resource description framework (RDF)

A structure of consistent semantics adopted by the World Wide Web Consortium (W3C) to promote encoding, exchange, and reuse of metadata.

results management

An approach to evaluating the outcomes of a process to determine whether that process was useful or valuable.

reusability

The extent to which software or other work-related artifacts can be used in more than one computing program or software system.

reusable learning object (RLO)

An approach to content development that consists of independent, self-contained, multimedia e-learning resources that breaks the content into chunks where each object can be swapped, interchanged, substituted, and exchanged as needed based on the characteristics of the learners and their specific learning needs.

right

A privilege; includes the right to privacy, confidentiality, and so on.

risk assessment

Determination of risk or danger, such as assessing for risk factors related to heart disease.

robot

A machine that looks like a living being in the fact that it resembles and behaves as a living being or part of a being and is capable of self-sufficient movement, such as pivoting, walking, or rolling with wheels; it automatically performs difficult or complicated actions, like a robotic hand that can grasp and move objects. An automated machine that is programmed to complete the routine tasks of a human being.

role-playing

A situation that allows students to try on real-life scenarios by filling either prescripted or ad-libbed roles (e.g., doctor, nurse, patient, or clinician) without the fear or pressure of putting another's life at risk while trying to determine the best course of action or find a solution to a fictitious patient's health issue.

root-cause analysis

Similar to failure modes and events analysis; analysis to discover why a process is faulty or produces an undesired result.

row

A record in a database; also known as a tuple.

safety culture

An organizational commitment to patient safety and the prevention of medical errors.

scaffolding

Adding initial support for a task and then gradually removing that support over time.

scareware

An email designed to scare the user into believing that their computer has been infected. The hacker seeks to gain remote access to the computer to "fix" it.

scheduling system

A system designed to track resources within a facility while managing the frequency and distribution of those resources. For example, a resource scheduling system provides information about operating room utilization or availability of intensive care unit beds and regular nursing unit beds.

scoring

The data mining process of applying a model to new data.

Scrum

An agile software development strategy that emphasizes collaboration, team autonomy or self-management, and flexibility to adapt to emerging business realities. This strategy organizes software developers into a team called a Scrum team to reach a common goal of creating market-ready products and services using iterative development cycles. The Scrum master is the agile servant–leader project manager who facilitates the Scrum team.

Scrum master

The agile servant–leader project manager who facilitates the work performed by the Scrum team; this leader is responsible for removing barriers and obstacles so that tasks may be

completed in order for the team to achieve its goals. The Scrum master must support the Scrum team and facilitate its ability to self-manage and self-organize. Since this is a highly collaborative process, the Scrum master must also establish and ensure a positive culture that is open to discussion and sharing of ideas. In addition, the Scrum master must assess and monitor the team's interactions with people external to the team to determine which exchanges with the Scrum team are beneficial and which are not in order to maximize the value generated by the Scrum team, which shields the Scrum team from distractions and work interruptions.

Scrum team

A team of software developers organized to reach a common goal of creating market-ready products and services.

Second Life (SL)

A proprietary virtual-reality tool that allows users to create virtual communities.

secure information

Information that is protected from error, unauthorized access, and other threats that can compromise its integrity and safety.

security

Protection from danger or loss. In informatics, one must protect against unauthorized access, malicious damage, and incidental and accidental damage; enforce secure behavior; and maintain security of computing, data, applications, information, and networks.

security breach

Any security violation.

self-control

Self-discipline. Strength of will.

sensor and activity-monitoring system

A system for tracking the activities of daily living of seniors and other at-risk individuals in their places of residence. For example, applications use sensors to detect anomalies or problems, such as faucets and stoves left turned on.

sentinel event

A term used by the Joint Commission to describe a patient safety incident that results in death, permanent harm, or serious temporary harm requiring intervention.

serious game

A game that has as its main purpose something other than entertainment—for example, an educational game designed for learning that is a subset of both education and fun.

server

A computer or a group of computers that link computers together or provide services to a group of computers.

shoulder surfing

Watching over someone's back as they are working on a computer. This is still a major way that confidentiality is compromised.

simulated documentation

A replicated documentation system that nursing students can use to learn how to access electronic health records and document nursing care.

simulation

An imitation of real-life events or circumstances; in nursing education, a replication of clinical scenarios developed to provide an opportunity for practice in a mock situation. A simulation can be web based, latex based, or virtual in a virtual world.

simulation scenario

A case or situation developed in a simulation setting to mimic an actual practice situation.

simulator

A mechanical or electronic device that provides an environment in which a simulation can occur. Some simulators can be quite large.

situational awareness

The ability to detect, integrate, and understand critical information that leads to an overall understanding of a problem or situation.

Six Sigma

Business management tactic that seeks to improve the quality of process outputs by identifying and removing the causes of imperfections (errors) and reducing inconsistency and variability in processes; Lean and Six Sigma are a complementary combination of activities that focus on doing the right steps and actions (Lean) and doing them right the first time (Six Sigma).

Small Computer System Interface (SCSI)

Set of standards for physically connecting and transferring data between computers and peripheral devices. The SCSI standards define commands, protocols, and electrical and optical

interfaces. Standardization among commercial products helps to ensure that devices will interface with many different systems.

smart device

Interactive electronic tool that is generally connected to other devices or networks using wireless protocols; able to understand simple user commands to help with the activities of daily living.

smartphone

A mobile device that combines cellular and mobile computing functions into one unit.

smart pump

Machine used to infuse medication that includes dose-checking technology and safeguards designed to help avert medication errors.

smart room

Patient room that is equipped with technologies to increase patient safety and improve patient care.

social determinants of health (SDOH)

The economic and social conditions in relation to their diffusion and distribution among the population that actually influence individual and group differences and disparities in health status. The conditions in the environment where we are born, play, grow, learn, live, work, and age that affect a wide range of health, functioning, and quality of life outcomes and risks. They have an effect on our life expectancy, morbidity, and mortality.

Social Determinants of Learning (SDOL)

An actionable model developed by Chamberlain University to address learning disparities and thus increase learning

opportunities to support nursing student diversity, equity, and inclusion.

social engineering

The manipulation of a relationship based on one's position in an organization. For example, someone attempting to access a network may pretend to be an employee from the corporate information technology office who then simply asks for an employee's digital ID and password. Another example of social engineering is a hacker impersonating a federal government agent. After talking an employee into revealing network information, the hacker basically has an open door to enter the corporate network.

social media

Communication tools, such as X (Twitter) and Facebook, that promote real-time information exchange.

social science

Collection of academic/scientific fields or disciplines concerned with the study of the human aspects of our world/environment.

software

A collection of data or computer instructions that tell a computer how to work. Software is divided into two types: system software (includes the operating system and other software necessary for the computer to function) and application software (allows users to complete specific tasks, such as word processors, spreadsheets, presentations, database managers, and media players).

software as a service (SaaS)

Cloud-based applications with the following benefits: the ability to quickly start using innovative or specific business apps that are scalable to individual needs, any connected computer can access the apps and data, and data are not lost if the hard drive crashes because the data are stored in the cloud.

somatosensory system

The network of neural structures that includes receptors and neurons in the body and brain that produce and convey information about the perception of touch or haptic perception, temperature, proprioception (body position), movement, and pain.

sound card

A computer expansion card that facilitates the input and output of audio signals to and from a computer under the control of computer programs. Also known as an audio card.

spatial audio

A 360 degree audio format that creates sound as though it is surrounding a person or an audience.

spear phishing

A targeted phishing scheme that takes advantage of specific information provided in an organization’s directory, thus allowing for a personalized scam email.

spreadsheet

Text and numbers located in cells on a grid and the software necessary to process formulas and other computations, such as creating graphs and charts.

spyware

A program that may contain malicious code that may attack or attempt to "take over" a computer. Spyware may also be nonmalicious in intent and simply monitor the user's behavior in an attempt to gain information about the user for targeted advertising.

stacking

The process of synthesizing the predictions from several models.

stakeholder

An individual or a group with the responsibility for completing a project and influencing the overall design and is the most affected by the success or failure of the system implementation.

standard

A benchmark, criterion, rule, norm, or principle.

standardized nursing terminology

Terms used in nursing that are in some way approved by an appropriate authority or general consent.

standardized plan of care

A plan that presents clinicians with treatment protocols to maximize their outcomes and support best practices.

static medium

Something that cannot be updated; for example, a print-based brochure may be outdated almost as soon as it is printed.

store-and-forward telehealth transmission

An application of telehealth care in which images and other clinical data are captured and transmitted to specialist clinicians.

Structured Query Language (SQL [pronounced "sequel"])

A database querying language rather than a programming language. SQL is a standard language for accessing and

manipulating databases. It simplifies the process of retrieving information from a database in a functional or usable form while facilitating the reorganization of data within the database.

Suicide Prevention Community Assessment Tool

Risk assessment method that addresses general community information, prevention networks, and the demographics of the target population as well as community assets and risk factors.

summary

A condensed version of a document that is designed to highlight its major points.

surveillance

The act of watching for trends in health-related data for early detection of health threats.

surveillance data system

A networked computer system designed to use health-related data trends to predict the probability of an outbreak of a contagious or infectious disease or to detect morbidity and mortality trends in a geographic area as a precursor to public health planning or response.

synchronous dynamic random-access memory (SDRAM)

The most common type of dynamic random-access memory found in personal computers.

syndromic surveillance

A specialized system of data collection that seeks to detect trends in the incidence and severity of a specific disease or health-related syndrome and plan the public health response.

synthesis

Combining parts of existing material or ideas into a new entity or concept.

systems development life cycle (SDLC)

Stages involved in the life of a system, typically an information system; a model used in the project management of a system's development effort, spanning from feasibility to its demise.

systems engineering

An approach where technology manufacturers partner with organizations to identify risks to patient safety and promote safe technology integration.

table

A collection of related records in a database.

task

An action that is value added and necessary. For example, some tasks come about because of work-arounds or for other unsubstantiated reasons. Tasks that are considered non–value added and are not necessary for the purpose of compliance or regulatory reasons should be eliminated from the future-state process.

task analysis

Analytical technique that focuses on how a task must be accomplished, including detailed descriptions of task-related activities, task characteristics and complexity, and the environmental conditions required for a person to perform that task.

technology

Method by which people use knowledge and tools. Knowledge used to solve problems, control and adapt to the environment,

and extend human potential. Generally, people use technology to refer to machines or devices, such as computers, and the infrastructure that supports them. For example, cell phones and planes are tangible technology; one can see and touch them but cannot see and touch the vast infrastructures supporting them, such as the wireless communications between the device (cell phone) and the cell towers and the electronic guidance used by the device (plane) to navigate the skies.

telecommunications

Broadcasting or transmitting signals over a distance from one person to another or from one location to another for the purpose of communication.

telehealth

Telecommunication technologies used to deliver health-related services or to connect patients and healthcare providers to maximize patients' health status. A relatively new term in the medical and nursing vocabulary that refers to a wide range of health services that are delivered by telecommunications-ready tools, such as a telephone, videophone, and computer.

telehealth care

Health services delivered by telecommunications-ready tools and usually supervised by a nurse or other clinician.

telemedicine

Health services delivered by telecommunications-ready tools and supervised or directed by a physician.

telemonitoring

Remote measurement of patients' vital signs and other necessary data.

telenursing

Health services delivered by telecommunications-ready tools and supervised or directed by a nurse.

telepathology

Use of telecommunications technology to facilitate the transmission and transfer of pathology data for the purposes of diagnosis, education, and research. Transmission and exchange of image-rich pathology data between remote locations.

telephony

Telephone monitoring of patients at their residences by off-site telenurses.

teleradiology

Use of telecommunications technology to electronically transmit and exchange radiographic patient images with the consultative text or radiologist reports from one location to another.

TELOS

An approach that provides a clear picture of the feasibility of a project; TELOS stands for technical, economic, legal, operational, and schedule.

terabyte (TB)

A unit of measurement for data storage capacity. One terabyte equals 1,024 gigabytes.

terminology

Vocabulary of technical terms used in a particular field, subject, science, or art; concerned with the collection, description, processing, and presentation of terms belonging to specialized areas of usage of one or more languages; nomenclature.

three dimensional (3D)

A geometric model of the physical universe in which we live; typically, the three dimensions are length, width, and depth (or height), although any three directions can be chosen as long as they do not lie in the same plane.

throughput

The amount of work a computer can do in a given time period; a measure of computer performance that can be used for system comparison.

thumb drive

Small, removable storage device.

tiering

The process of storing data in layers according to how frequently they are used in a database.

TIGER initiative

The work of the Technology Informatics Guiding Education Reform team. This team of nursing leaders developed a vision for utilizing information technology to transform nursing practice.

total cost of ownership (TCO)

A comprehensive assessment of IT and related costs of a software solution, including hardware, software, maintenance, sustainability, management, communications, support, training, opportunity costs due to downtime, and productivity losses.

touch pad

An alternative to using a mouse. A device that senses the pressure of the user's finger along with the movement of the finger on the touch pad to control input positioning.

touch screen

A display used as an input device for interacting with or relating to the display's materials or content. The user can touch or press on the designated display area to respond, execute, or request information or output.

transforming

The act of changing the nature, character, function, state, or condition of something.

translational bioinformatics

The development of storage, analytic, and interpretive methods to optimize the transformation of increasingly voluminous biomedical and genomic data into proactive, predictive, preventive, and participatory information.

translational informatics

The application of research informatics to translational research in order to close the gap from research to the bedside to improve the health of patients and the community.

translational research

Research that is conducted with a vision toward transforming clinical nursing practice (i.e., translating the results into practice).

transparent wisdom

Applying knowledge in a practical way or translating knowledge into actions without conscious thought.

treatment/payment/operations (TPO)

The treatment of patients, the payment for services, or the operations of the entity. Providers and other covered entities were not originally required to include in the accounting any disclosures that were made to facilitate the treatment of

patients, the payment for services, or the operations of the entity (i.e., the TPO exception); this exception ended in January 2011 for providers that recently implemented electronic health record (EHR) systems. For those providers with EHR systems that were implemented before passage of the Health Information Technology for Economic and Clinical Health (HITECH) Act, the TPO exception ended in January 2014. It is easy to understand why this exception ended; because all providers must implement comprehensive EHR systems, it would be very easy to generate an electronic record with an accounting of anyone who accesses a patient's record.

triage

The process of assessing patients who are ill or injured and determining the need for intervention based on the severity of the health issue. Some software programs used in telehealth monitoring systems provide this function by comparing actual data with a preset standard and then alerting clinicians that an intervention is necessary.

Trojan horse

Malicious code, capable of replicating within a computer, that is hidden in data or a program that appears to be safe.

TRUSTe

One of the two most common symbols that internet users look for to identify trusted health sites.

truth

Fact; certainty; or sincere action, character, and fidelity.

tuple

A record in a database; also known as a row.

tutorial

Learning materials available to the learner, who must then be self-directed to study the specific topical area presented.

über-connected world

Using social media tools, such as wikis, blogs, and other social networks, to connect employees and people globally. Companies are finding that über-connected workplaces are not only about applying a new set of tools but also about adopting a cultural paradigm shift to establish an open environment where employees are supported and encouraged to collaborate, share, transform, and innovate virtually.

ubiquity

State of being everywhere at once (or seeming to be everywhere at once). Presence in many places, especially simultaneously. With changing models of healthcare delivery, information and knowledge should be available anywhere.

uncertainty

Ambiguity, insecurity, or vagueness.

unified communications (UC)

A communication solution, framework, or standard that refers to a wide range of products and services or diverse communication tools that are integrated to enhance communication with the goal of increasing productivity and enhancing the user experience (UX) while facilitating an excellent means for digital collaboration and teamwork to support a shared approach to patient care; an interface that incorporates enterprise communication tools, software, and hardware components into a single or unified streamlined interface where people can use

different communication tools in a single or unified application extending the way communication devices and data and information can be exchanged.

universal serial bus (USB)

A means of connecting a myriad of plug-in devices, such as portable flash drives, digital cameras, MP3 players, graphics tablets, and light pens, using a plug-and-play connection, without rebooting the computer.

unstructured data

Data that are not contained in a database; data residing in text files, which can represent more than 75% of an organization's data; data that are not organized or that lack structure.

usability

The ease with which people can use an interface to achieve a particular goal; issues of human performance during computer interactions for specific tasks within a particular context.

USB flash drive

A portable memory device that uses electronically erasable, programmable ROM to provide fast, permanent memory. A USB flash drive is typically a removable and rewritable device that includes flash memory and an integrated universal serial bus (USB) interface. Because of its small size, it is portable, durable, and dependable and obtains its power from the device it is connected to via a USB port.

use case

The description of a distinct situation in which a specific product or service could possibly be used.

user experience (UX)

The user's experience from interacting with an object, a product, or a service. It is connected to the term *usability* and refers to the design of products and services with the user in mind in order to meet the user's needs.

user friendly

Describes programs and peripherals that make it easy to interact with or use computers or other technologies. Design of a program to enhance the ease with which the user can utilize and maximize the productivity from computer programs.

user interface (UI)

A mechanism or system that users utilize to interact with programs.

values

Basic or fundamental beliefs that guide actions.

veracity

Right to truth.

video adapter card

A board or card that is inserted or plugged into a computer to provide display capabilities.

videopod

A podcast that provides video in addition to audio functionality; self-contained system with a video transmitter.

virtual desktop interface (VDI)

The process of running a user desktop inside a virtual machine on a centralized server in a data center. VDI is a variation on the client-server computing model, sometimes referred to as server-based computing. It enables fully personalized desktops for each individual user with all the security and simplicity resulting

from centralized management. Also known as virtual desktop infrastructure.

virtual memory

The use of hard disk space on a temporary basis when the user is running many programs simultaneously. This temporary use frees up RAM to allow programs to run simultaneously and seamlessly.

virtual private network (VPN)

An encrypted connection service that protects privacy and anonymity when a device is connected to the Internet.

virtual reality (VR)

Technology that simulates reality in a virtual medium.

virtual simulation

A simulation using a three-dimensional virtual world or environment that resembles the real-world setting and activities being simulated.

virtual world

A world that exists in cyberspace where people can establish avatars, purchase land, and interact with others. Emerging virtual worlds, such as Second Life, are changing the meaning of social networking. It is a live, online, interactive three-dimensional environment in which users interact using speech or text via a personalized avatar. Access requires a modern computer and an internet connection.

virtue

An ideal toward which we should strive that provides for the full development of our humanity. Attitude or character trait that enables us to be and to act in ways that develop our highest

potential—for example, honesty, courage, compassion, generosity, fidelity, integrity, fairness, self-control, and prudence. Like habits, virtues become characteristics of a person. The virtuous person is the ethical person.

virtue ethics

Theory that suggests that individuals use power to bring about human benefit. One must consider the needs of others and the responsibility to meet those needs.

virus

Malicious code that attaches to an existing program and executes its harmful script when opened.

voice recognition

A type of software that allows the user to input data or navigate the web using voice commands. Voice interactivity should help to reduce the disparity associated with those who have limited keyboard or mousing skills.

waterfall model

An early systems development life cycle model that is linear in nature; when one phase ends, the next phase begins, unlike in its modern counterparts that stress iterative development.

wearable device

A device that a person can don or put on like other articles of clothing, watches, jewelry, and other accessories that provide remote monitoring of physiological parameters in care settings, including the patient's own home.

wearable technology

The study or practice of inventing, designing, building, or using miniature body-borne computational and sensory devices.

Wearable computers may be worn under, over, or in clothing or may actually be the clothes themselves.

web based

Originating from the World Wide Web.

webcast

Media distributed over the internet as a broadcast, which relies on streaming media technology to facilitate downloading and participation. Such broadcasts could be distributed in real time or live or recorded for asynchronous interaction.

web enhanced

That which uses the World Wide Web to enhance or promote functions or tasks, such as effective learning and skill acquisition.

webinar

Web-based seminar. Web conferencing that allows presenters to share their computer screen or files and collaborate with the audience; attendance is controlled by an access code.

weblog

A website that contains the contributions of single or multiple users about a particular topic or issue. Similar in nature to a threaded discussion board or a personal diary, weblogs (also known as blogs) can provide insight into the perceptions of the contributors about the topic.

web publishing

The design and development of web pages that include links to digital files that are uploaded to web servers, thereby making these files accessible to others via web browsers.

web quest

A search of the World Wide Web for information.

web server

Multifunctional telehealthcare platform for receiving, retrieving, and/or displaying patients' vital signs and other information transmitted from telecommunications-ready medical devices.

wide area network (WAN)

A system of connected local area networks (LANs).

Wi-Fi

A wireless technology, owned by Wi-Fi Alliance, that is used to improve the interoperability of wireless networking devices.

Wi-Fi hotspot

A resource or wireless access point that is usually provided in a public location, such as cafés, libraries, hotels, airports, and even grocery stores.

wiki

Server software that allows users to create, edit, and link web page content from any web browser. Server software that supports hyperlinks. The simplest online database, used to develop collaborative websites.

wireless

A way to transmit signals without using wires or cables, such as through radio or microwaves.

wireless mobile computing

Mobile computing without the need for wires or cables to connect to a network.

wisdom

Knowledge applied in a practical way or translated into actions; the use of knowledge and experience to heighten common sense and insight to exercise sound judgment in practical matters. Sometimes thought of as the highest form of common sense, resulting from accumulated knowledge or erudition (i.e., deep, thorough learning) or enlightenment (i.e., education that results in understanding and the dissemination of knowledge). Wisdom is the ability to apply valuable and viable knowledge, experience, understanding, and insight while being prudent and sensible. It is focused on our own minds and is the synthesis of our experience, insight, understanding, and knowledge. Wisdom is the appropriate use of knowledge to solve human problems. It is knowing when and how to apply knowledge.

word processing

Creating documents using a word processing software package, such as Microsoft Word.

work-around

A way invented by users to bypass the system to accomplish a task; usually indicates a poor fit of the system or technology to the workflow or user. Devised method to beat a system that does not function appropriately or is not suited to the task it was developed to assist with. For example, a nurse might remove the armband from a patient and attach it to the bed if the barcode reader fails to interpret barcodes when the bracelet curves tightly around a small arm.

workflow

A progression of steps (tasks, events, and interactions) that constitute a work process, involve two or more persons, and

create or add value to the organization's activities. In a sequential workflow, each step depends on the occurrence of the previous step; in a parallel workflow, two or more steps can occur concurrently. Sometimes the term *workflow* is used interchangeably with *process* or *process flow*, particularly in the context of implementations. A sequence of connected steps in the work of a person or team of people—that is, the process or flow of work within an organization; a virtual illustration of the "real" work or steps (flow) that workers enact to complete their tasks (work). The purpose of examining and redesigning workflow is to streamline the work process by removing any unnecessary steps that do not add value or might even hinder the flow of work.

workflow analysis

Not an optional part of clinical implementations but rather a necessity for safe patient care fostered by technology. The ultimate goal of workflow analysis is to create a future-state solution that maximizes the use of technology and eliminates non–value-added activities. Although many tools and methods can be used to accomplish workflow redesign (e.g., Six Sigma and Lean), the best method is the one that complements the organization and supports the work of clinicians.

work process

See workflow.

World Wide Web (WWW)

An international network of computers and servers that offers access to stored documents written in HTML code and access to graphics, audio, and video files.

worm

A form of malicious code. A self-replicating computer program that uses a network to send multiple copies of itself to other computers, subsequently tying up bandwidth and incapacitating networks.

yottabyte (YB)

A unit of information or computer storage equal to 1 septillion bytes.

Youth Risk Behavior Surveillance System (YRBSS)

An epidemiological survey conducted by the Centers for Disease Control and Prevention to identify and track the most common health risk behaviors that lead to illnesses and mortality among youth.

zero day attack

A technique whereby a hacker searches for and exploits software vulnerabilities before the vendor is able to release a patch or a fix.

zettabyte (ZB)

A unit of information or computer storage equal to 1 sextillion bytes.

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The model features a three-dimensional illustration of three entwined, inverted cones labeled K A, K G, and K D. The three labeled cones converge to create a new cone labeled K P. Encircling these cones is a feedback loop. The entire composition is situated on a platform featuring repeated words such as information, data, bytes, and bits. K A indicates knowledge acquisition; K D indicates knowledge dissemination; K G indicates knowledge generation; and K P denotes knowledge processing.

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The stages are as follows. 1. Knowledge acquisition involves orientation and continuing education. 2. Knowledge surfacing encompassing explicit and tacit knowledge includes reflection on practice and mentoring. 3. Knowledge sharing and dissemination includes utilizing social media, intranet, and email. 4. Knowledge development involves activities like data mining, information mapping, and information retrieval. 5. Knowledge processing encompasses data analysis and report generation. 6. Outcomes evaluation involves providing feedback for knowledge use and generating new knowledge. The cycle then returns to the initial stage of knowledge acquisition.

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The threats are as follows. Human errors like incorrect data entry and spelling errors; malware such as viruses, worms, spam, and ransomware; transmission errors involving connectivity issues, data corruption, and lost data; and machine errors including hardware failures and software crashes.

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The primary components are arranged around a central motherboard, each illustrated with accompanying photos. 1. Motherboard: Comprising the power supply, heat sink, C P U or processor, RAM, and memory with a hard drive. 2. Input peripherals: Encompassing the keyboard, mouse, microphone, and other input devices like U S B drives and touch pens. 3. Output peripherals: Including the monitor, printer, speakers, and other output devices such as projectors. The sequential flow of data through the computer components follows this process. Input peripheral: Inputs or enters and edits data. Processing and memory: The C P U or processor processes the data, and the RAM retains data and information while the computer is on. Output peripheral: Displays the processed data and information.

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Benefits include transparency, as users are encouraged to modify or enhance existing versions or create new ones through collaborative efforts. The collaborative efforts emphasize that publicly accessible source code is shared with users and developers. Stumbling blocks include a lack of interoperability and limited awareness or familiarity of people with open source concepts.

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The advantages include the following. Agile deployment; Increased productivity; Pay as you go as needed; Sustainable; Reliable; Situational and context-driven; Enhanced collaboration; Scalable with dynamic ramp-up or dynamic ramp-down; Resources are shared and distributed; Flexible; Less capital expenditures; User-distinct encounters and experiences; and Market adaptability.

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The illustration features three nested clouds pouring five water droplets. Clouds represent service models such as: 1. S a a S, software as a service; 2. P a a S, platform as a service; 3. I a a S, infrastructure as a

service. Droplets represent key cloud computing characteristics, including on-demand self-service, resource pooling, broad network access, rapid elasticity, and measured services.

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The sequence from cognitive informatics to usable systems unfolds in the following manner. 1. Cognitive informatics: Focuses on studying the brain and human information processing. 2. Informs system design: Involves modeling cognitive processes and considering human mental workload. 3. Usable systems: Result in designs that are easy and intuitive, supporting nursing practice and decision-making.

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The progression from bottom to top includes: Harvesting external data, which is processed to become useful or meaningful external information; Synthesizing data and information in an iterative continuum; Transforming this into knowledge, application of knowledge, and finally, wisdom as internal outcomes leading to actions and decisions.

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The key roles include Informatics Nurse Specialist, I N S, functioning as a project manager, consultant, educator, researcher, product developer, decision support, outcomes manager, advocate, policy developer, clinical analyst, and entrepreneur. Expertise needed spans users, modifiers, and innovators. Competencies needed encompass technical, utility, and leadership skills.

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The P H I vulnerabilities are as follows. Unintentional breaches: Unsecured terminals; Loss of devices; Unsecured passwords. Outside attacks: Hackers; Worms, viruses, spam; Theft. Intentional breaches: Malicious insiders; Social media use; Unauthorized access. Network issues: Unencrypted transmissions; Firewall failure.

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The phases of D S D M include: 1. Feasibility. 2. Business studies. 3. Functional model iteration involving creating a functional prototype, agreeing on a plan, identifying the prototype, and reviewing it. 4. Design and build iteration involving agreeing on a plan, identifying design prototypes, reviewing the design prototype, and creating design prototype. 5.

Implementation involving reviewing the business, implementing, training users, obtaining user approval, and establishing user guidelines.

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The siloed data includes laboratory, X-ray, pharmacy data; clinical E H R data; and demographic information. When combined, these data sources create integrated data, providing a comprehensive 360-degree holistic view of the patient.

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The flow begins with the identification of the advanced practice nurse, including their name and I D number. Subsequently, a patient, identified by name and I D number, visits the advanced practice nurse. The flow also indicates the assignment of the patient to the nurse, with the nurse’s name and I D number included in this process.

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The illustration features a man seated at a computer on a swivel chair with a footrest, positioned next to a window. Labeled elements include soft incoming light through the window, thighs parallel to the floor, an

adjustable seat, feet flat on the floor or footrest, keyboard at elbow height, and display at eye level or slightly below of about 18 to 28 inches.

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A central circle is labeled perceive, task, act, with an up arrow on the left and a down arrow on the right. A divided box covering the central circle includes a computer interface on the left and computer characteristics on the right. Two circles above the box represent clinician processes and clinician characteristics, while two circles below the box represent patient data and patient status. A larger circle covering the entire illustration includes information on the left, exchange on the right, and context on the top.

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The flow begins with user ability and task demands, converging into the context of technology. The technology then branches into two paths: 1. User ability and, or human-technology interface less than task demands, leading to success. 2. Task demands surpassing user ability and, or human-technology interface, resulting in failure.

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The diagram consists of four lanes representing Patient, Physician, Pharmacy, and Nurse. Steps include the following. 1. Patient: Presents to emergency department; Admitted to the hospital. 2. Physician: Admits the patient; Gathers information about all medications taken at home; Orders medications in C P O E. 3. Pharmacy: Reviews patients admitted to the hospital; Selects the patient and reviews medications ordered by the physician; Reviews medications using multiple sources, including previous E H R information on the patient, to verify typical dose and whether a generic or brand name; Reconciles any discrepancies or questions they have by contacting the physician or nurse. 4. Nurse: During admission process gathers information about all the medications they are taking at home, including over the counter, O T C, and supplements; Documents in the E H R and reviews medications ordered for the patient.

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The patient portal, National Health Information Exchange, and patient outreach home care converge to form Hospital X Y Z. Hospital X Y Z features reporting and analytics, data mining, performance

metrics involving financial, healthcare, census, staffing, and personnel, informative exchange, satellite clinics, doctors' offices, other hospitals, and care facilities. Hospital X Y Z further leads to patient registration, including outpatient and patient admission. E H R components within the system include clinical documentation, computerized physician order entry, clinical decision support, social determinants of health, physical therapy, diagnostic testing, laboratory, radiology, social services, and financial services.

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The ways include the following. Store data electronically for exchange and reporting; Put accountability into nursing care; Standardize care through use of shared protocols; Improve ease of care coordination; Provide decision support to encourage evidence-based practices; Automate clinical processes; Measure clinical risks; Provide decision support; Enhance evidence-based practice; Improve practice workflows; Retain patient data and information, building a more complete picture of the patient for all care providers to access; Reduce errors; and Leveraged for clinical analysis.

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In the first section, three circles overlap to represent the user, encompassing patient or guardian or caregiver, healthcare provider, and ancillary personnel. The second part focuses on health information technology, H I T, with four overlapping circles indicating developer, user or healthcare provider, researcher, and I T personnel. These components lead to a flow diagram of patient safety, emphasizing criteria such as the absence of data entry errors, timely data delivery, intact and complete data with no missing data, appropriate use of default values, exclusive electronic system utilization for patient care, integrity of patient data, that is, data associated with the correct patient, and capturing the latest information for reporting.

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The rain symbolizes health problems and risks. The umbrella encompasses key elements, including building relationships with values and preferences, and respect; ensuring understanding through plain language, clear dialogue, follow-up, technology, and easy navigation; and partnering with peer support, resources, and education. Underneath the umbrella, the concept is associated with achieving better health.

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The process begins with patients seeking care, their data sent to hospitals and healthcare providers. From there, it reaches a Health Information Organization, continuing through data to a Cloud environment involving data sharing and events and outbreaks monitoring. The Cloud environment, through data generated from various sources like retail sales, Google searches, E H R, Health Information Exchange, and C D C, leads to analytical tools and report generation. The final stages involve the dissemination of reports to Health Departments for analysis and reporting.

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In the first part, three nested circles outline key goals: Thrive, including E-health, reducing health disparities, prevention and wellness promotion, monitoring and improving population health; for individuals, families, populations, and communities; emphasizing the principles of provide, partner, protect, and prevention comprising primary, secondary, and tertiary. The second part features a cyclic diagram including data acquisition and representation, analysis of data, integration of

information, knowledge management, and change management in public health informatics.

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The stages are as follows. 1. Hazard identification: What health problems are caused by the pollutant? 2. Dose-response assessment: What are the health problems at different exposures? 3. Exposure assessment: How much of the pollutant are people exposed to during a specific time period? How many people are exposed? 4. Risk characterization: What is the extra risk of health problems in the exposed population?

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The horizontal axis spans from 2005 to 2025 in increments of 5. Two trend lines are plotted. A decreasing trend for healthcare workers and an increasing trend for population costs. Both lines intersect at 2015. The area to the right of the intersection reads, Technology fills the gap with telenursing and nurse help desks to handle many patients due to the shortage. Text alongside the graph reads as follows. 1.7 trillion dollars in healthcare costs; 34 million population greater than 65 years old. 4.2 trillion dollars in healthcare costs;

78 million population greater than 65 years old. R N population: Expected to grow from 2.71 million in 2012 to 3.4 million in 2022. Year 2022: Nursing shortage of 1.05 million. Even if the nursing graduate statistics remain the same, there will be a need for an additional 260,000 R Ns by the year 2025. Nearly 700,000 nurses are projected to retire or leave the labor force by 2024.

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The flow diagram includes the following path. 1. Review: Mining data for healthcare solution. 2. Analysis: Who would benefit from your review. 3. Referral: Establish process and advocate for those patients. 4. Provide: Equipment and monitor. 5. Intervene: Telenurses respond using standardized protocols. 6. Aggregate data: Create data warehouse. 7. Evaluation: Determine patient support and care needed to remain in their home. 8. Maintenance: Reassess patient and equipment functionality and needs. The three photos feature the following. 1. A healthcare professional interacts with an elderly couple. Accompanying text reads, Typical patients: Chronically ill, Frail elderly, Mentally ill, and Acute episodic events. 2. Telenurses: Two nurses interact with a healthcare professional through a computer. 3. Two healthcare professionals have an

interaction in a computer server room. Accompanying text reads, Ancillary support personnel: Deliver and maintain equipment; Update and maintain information systems and user interfaces.

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The interactions are as follows. Learner to content: Flashcards; R S S feeds; YouTube videos; F A Q forums. Learner to instructor: Lessons; Quizzes and tests; Video conferences; Emails; Projects. Learner to learner: Chat; Discussion forums; Blogs; Wikis. Learner to interface: Computer-assisted instruction; Learning management system; Simulations; Virtual reality.

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The illustration features a table with an upward arrow on either side. The table is titled Commitment to effective social media use takes time. The row entries are as follows. Row 1. Build community: Facebook; LinkedIn; X, Twitter; Ning. More than 5 to 10 hours per week. Row 2. Publish: Blogger; WordPress; Typepad; Flickr; YouTube. More than 3 to 5 hours per week. Row 3. Participate: Facebook; LinkedIn; X, Twitter; Hootsuite; Seesmic; TweetDec.

More than 30 minutes per day. Row 4. Promote: Digg; X, Twitter; BizSugar; HelloTxt; Ping.fm; ShareThis; AddThis; dlvr.it. More than 20 minutes per day. Row 5. Listen: Google Alerts; Social Mention; Attensity 360; Scout Lab; Radian. More than 15 minutes per day. Row 6. Read: Google Alerts. More than 15 minutes per day.

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The two research subjects are as follows. Quantitative: Focus on numbers and numeric values; Who, what, where, when; Match with outcomes about knowledge and comprehension, define, classify, recall, recognize; Allows for measurement of variables; Uses statistical data analysis; May be generalized to greater population with larger samples; Easily replicated. Qualitative: Focus on text and narrative from respondents; Why, how; Match with outcomes about application, analysis, synthesis, evaluate; Seeks to explain and understand; Ability to capture, elusive, evidence of student learning and development. The two methods converge to form mixed methods, including experimental research and translational research.

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During the data pre-processing stage, the raw data, portrayed as a diamond, goes through a conversion process into target data, symbolized by three smaller diamonds. This transformation culminates in pre-processed data. In the pattern recognition phase, the transformed data exposes emerging patterns, represented by a series of ascending bars. Ultimately, this progression results in the acquisition of knowledge, as depicted by an illustration of the brain.

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The flowchart comprises four levels, from top to bottom. Level 1 comprises Node 0. Node 0 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 22.1; 132. Reassault: 77.9; 464. Total: 100.0; 596. Level 2 consists of Node 1 and Node 2 branching from Node 0. Women's perception of safety: Adjusted P-value equals 0.000, Chi-square equals 25.580, degrees of freedom equals 1. Node 1 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 9.5; 18. Reassault: 90.5; 171. Total: 31.7; 189. Node 2 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 28.0; 114. Reassault: 72.0; 293. Total: 68.3; 407. Level 3 consists of Node 3 and

Node 4 branching from Node 1; and Node 5 and Node 6 branching from Node 2. Node 3 and 4 are obtained from controlling behaviors: Adjusted P-value equals 0.037, Chi-square equals 6.785, degrees of freedom equals 1. Node 5 and 6 are obtained from controlling behaviors: Adjusted P-value equals 0.024, Chi-square equals 5.100, degrees of freedom equals 1. Node 3 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 14.0; 16. Reassault: 86.0; 98. Total: 19.1; 114. Node 4 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 2.7; 2. Reassault: 97.3; 73. Total: 12.6; 75. Node 5 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 31.2; 91. Reassault: 68.8; 201. Total: 49.0; 292. Node 6 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 20.0; 23. Reassault: 80.0; 92. Total: 19.3; 115. Level 4 consists of Node 7 and Node 8 branching from Node 6. Node 7 and 8 are obtained from non-domestic violence arrest: Adjusted P-value equals 0.020, Chi-square equals 5.445, degrees of freedom equals 1. Node 7 displays three columns: Category, percentage, and n. The row entries are as follows. No reassault: 10.9; 6. Reassault: 89.1; 49. Total: 9.2; 55. Node 8 displays three columns:

Category, percentage, and n. The row entries are as follows. No reassault: 28.3; 17. Reassault: 71.7; 43. Total: 10.1; 60.

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The trio of triangles, symbolizing input, throughput, and output, collectively represents the concept of storage. Each triangle indicates the following. 1. Input: Ingesting big data involves constructing the dataset through the following steps: locating the data, capturing the data, cleaning the data, normalizing the data, and aggregating the data. 2. Throughput: Explore, track, and extract data through processes such as data mining, which includes querying or modeling. Further processing involves interpreting the data, understanding the data, and evaluating the data, that is, refining the query or model as needed. 3. Output: Apply or use the data and report the output data.

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Under the head Example of a Phishing Scam Email, the text reads as follows. Check suspicious emails for grammar and spelling errors, generic greetings, for example, User, Dear, or Dearest, or requests for immediate action or personal information, for

example, passwords or bank account numbers. Some phishing emails may appear to come from your bank or another trusted organization. Think carefully about why a seemingly legitimate organization might be asking for information it should already have or why it might need to know what it is asking for. Be aware of your organization's procedures for reporting phishing scams, and do so immediately. Source line reads, Data from: Pennsylvania State University, Office of Information Security. No date. What is phishing? h t t p colon double forward slash phishing dot p s u dot e d u forward slash what hyphen is hyphen phishing.

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The text continues as follows. The database example provided here reflects the faculty listing for a school of nursing. The table that contains the data is identified by the name, Faculty. The faculty members are categorized by the following fields, columns: Last Name, First Name, Department Affiliation, Office Phone Number, Office Location, and User I D. Each faculty member's information is a record, tuple, or row. Using the S Q L command SELECT, all the records in the, Faculty, table can be selected: SELECT, asterisk FROM Faculty This command would SELECT all, asterisk, of the records FROM the table

known as FACULTY. The asterisk, asterisk, is used to select all the columns.

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The model features a three-dimensional illustration of three entwined, inverted cones labeled K A, K G, and K D. The three labeled cones converge to create a new cone labeled K P. Encircling these cones is a feedback loop. The entire composition is situated on a platform featuring repeated words such as information, data, bytes, and bits. K A indicates knowledge acquisition; K D indicates knowledge dissemination; K G indicates knowledge generation; and K P denotes knowledge processing.

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The table consists of six columns: Alternative, Good Consequences, Bad Consequences, Do Any Rules Nullify, Expected Outcome, and Potential Benefit more than Harm. The row entries are as follows. Row 1. 1. Wait until the crisis is resolved. No policy violation; Patient rights safeguarded. Not the best use of the professor's time. No. Best: Crisis will require a short time; Worst: Crisis may take a long time. Patient rights protected; Collegial relationship jeopardized; Patient rights may take precedence. Row 2. 2. Delegate to another staff member. No policy violation. Other staff may be equally busy or might not be as familiar with all patients. No. Best: Assignments will be completed; Worst: May not have benefit of expert advice. Confidentiality of records is assured; May compromise student learning; Patient rights may take precedence. Row 3. 3. Log on to the

system for the professor. Professor can begin making assignments. May still be a violation of policy regarding system access. Rules regarding access to medical records. Best: Assignments can be completed; Worst: Abuse of access to information. Potential compromise of records; Patient in crisis is cared for.

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