FIFTH EDITION

NURSING INFORMATICS

and the Foundation of Knowledge

Dee McGonigle
Kathleen Garver Mastrian

FIFTH EDITION

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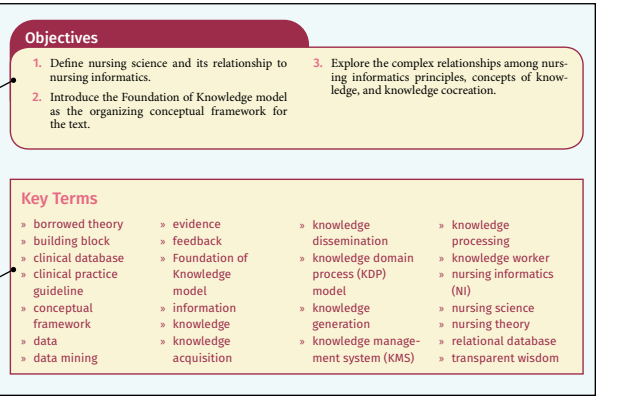
The Pedagogy

Nursing Informatics and the Foundation of Knowledge, Fifth 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.



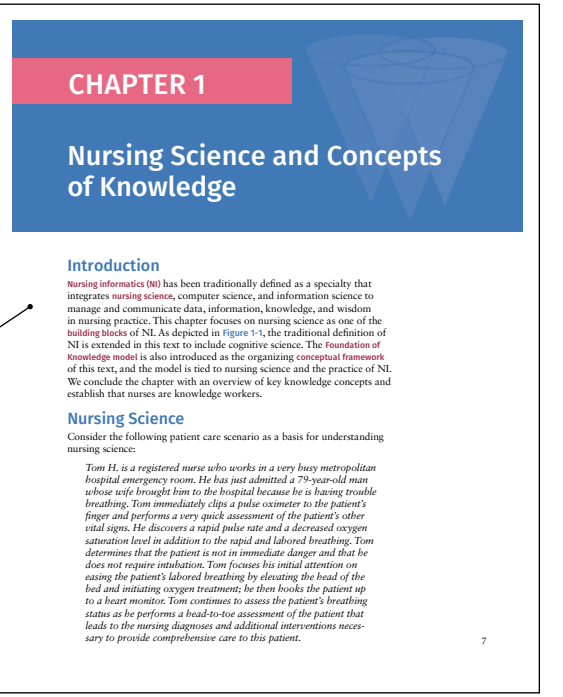
Objectives

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 cocreation.

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

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.



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 who works in a very 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 performs a very quick assessment of the patient's other vital signs. He discovers a rapid pulse rate and a decreased oxygen saturation level in addition to the 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.

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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 e-health 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 e-health 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.

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. Shauna Leighton (2017), in a blog post on Seismic, 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). She recommended the following:

- "Engaging patients with insights that are conversational and contextual, and adjusting based on the situation to respond in real time" (para. 7)
- Providing the healthcare team with AI to assist with personalizing their actions to meet the patient's needs
- "Empowering patients who want to actively participate and engage in their health with intelligent guidance and support when needed" (para. 7)

Leighton said it best when she stated that

> *[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.

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 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 five-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: Mid Cheshire NHS trust improve patient care with IT orchestration by CDW*. https://uk.cdw.com/files/5215/6285/7057/Case_Study_Mid_Cheshire_NHS_Trust_Final.pdf

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Contents

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 Dee McGonigle cofounded with 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 BS through 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 of 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 of the chapters based on technological advancements and changes to the healthcare arena, including reimbursement mechanisms for services. We have 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. In Section II, the previous four chapters were narrowed to three. New Chapters 6, *History and Evolution of Nursing Informatics*, and 7, *Nursing*

Informatics as a Specialty, were developed, and appropriate material from the previous Chapters 6, 7, and 8 were assimilated. This section ends with an updated Chapter 8, *Legislative Aspects of Nursing Informatics: HITECH and HIPAA* (formerly Chapter 9). Section III contains the same five chapters, although all were updated, and Chapter 13, *Workflow and Beyond Meaningful Use* (formerly Chapter 14), now reflects the payment models and reimbursement issues that we are adjusting to after meaningful use has gone away. Section IV contains the same five chapters with updated content and some name changes to reflect the current status of informatics and health care. Chapter 15 was renamed to *Informatics Tools to Promote Patient Safety and Quality Outcomes*, and Chapter 16 has been changed to *Patient Engagement and Connected Health*. Section V went from three to two chapters: Chapter 19 (formerly Chapter 20) was updated, and the new Chapter 20, *Simulation, Game Mechanics, and Virtual Worlds in Nursing Education*, had content from the former Chapters 21 and 22 integrated during its development. Section VI was renamed to *Research Applications of Nursing Informatics*. It still has the same four chapters, which have been updated, but the first chapter in this section, 21, was renamed to reflect nursing research; its new name is *Nursing Research: Data Collection, Processing, and Analysis*. Section VII went from three to two chapters. Because emerging technologies are discussed throughout the text, the chapter focusing specifically on that was removed. The two chapters that remain are Chapter 25, *The Art of Caring in Technology-Laden Environments*, and the new Chapter 26, *Nursing Informatics and Knowledge Management*. In addition, the ancillary materials have been updated and enhanced to include competency-based self-assessments and mapping the content to the current NI standards.

In this fifth edition, we have once again reviewed and updated all of 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, interprofessional collaboration, and pandemic response. There is a section describing a virtual reality product with access information for the reader; this product can be accessed in 2D as well as 3D. This edition remains 26 chapters long, with Chapter 25, *The Art of Caring in Technology-Laden Environments*, being enhanced. We have replaced Chapter 26 with *Our Expanding Realities* to examine the emerging technologies evolving our sense of reality that will impact the future of health care, nursing practice, nursing informatics, and patient care. To help you consider the disruptive forces affecting our realities, we have provided a glimpse of patient experiences in future health care, care bots, cyborgs, and AI. Through our use of nursing informatics in the integration of evolving technologies, we impact our reality, the reality of the healthcare industry, and the reality of our patients. In addition, the ancillary materials have been updated and enhanced to include competency-based self assessments, mapping the content to the current NI standards, and activities for both undergraduate and graduate nursing students.

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 (*Nursing Science and Concepts of Knowledge*), 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 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 Era 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 Era 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 introduces a new chapter entitled *Our Expanding Realities*.

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
- 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 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.

Acknowledgments

We are deeply grateful to the contributors who provided this text with a richness and diversity of content that we could not have captured alone. Joan Humphrey provided social media content integrated throughout the text. We especially wish to acknowledge the superior work of Alicia Mastrian, graphic designer of the Foundation of Knowledge model, which serves as the theoretical framework on which this text is anchored. We could never have completed this project without the dedicated and patient efforts of the Jones & Bartlett Learning staff, especially Joanna, Christina, Madelene, and Erin, all of whom fielded our questions and concerns in a very professional, respectful, and timely manner.

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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 NI 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!

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SECTION I

Building Blocks of Nursing 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 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, can also advance the nursing science knowledge base. The development of knowledge tools, such as the automation of decision-making and 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 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.

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, 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.

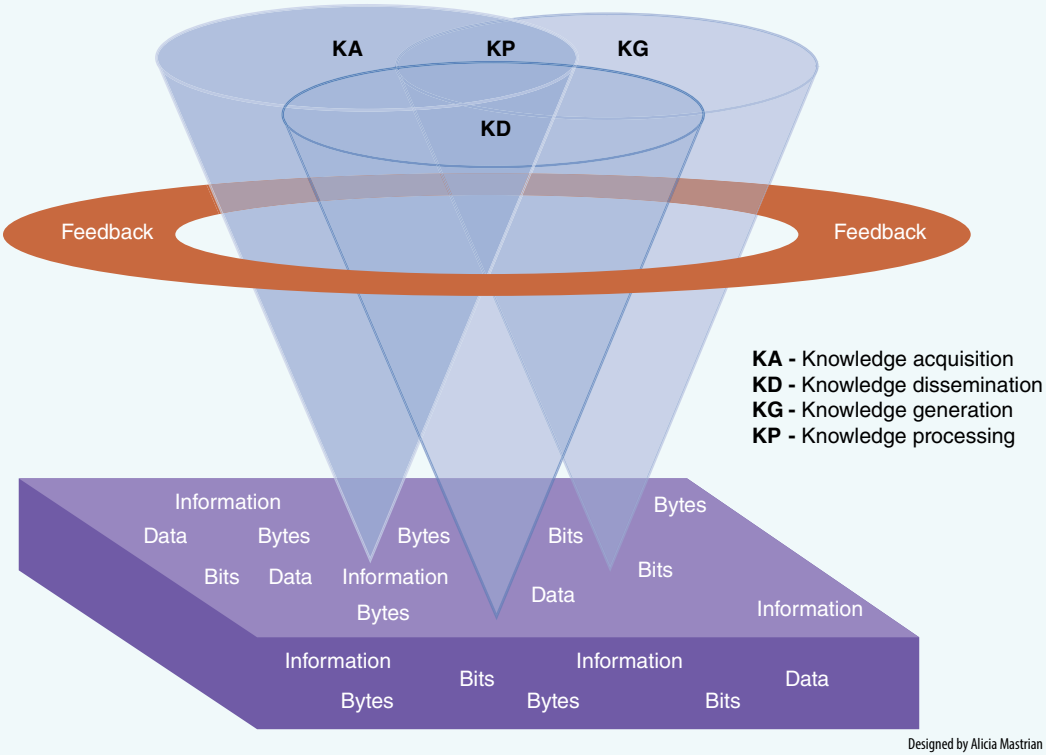

Figure I-1 Foundation of Knowledge Model

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 cocreation.

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 who works in a very 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 performs a very quick assessment of the patient's other vital signs. He discovers a rapid pulse rate and a decreased oxygen saturation level in addition to the 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.*

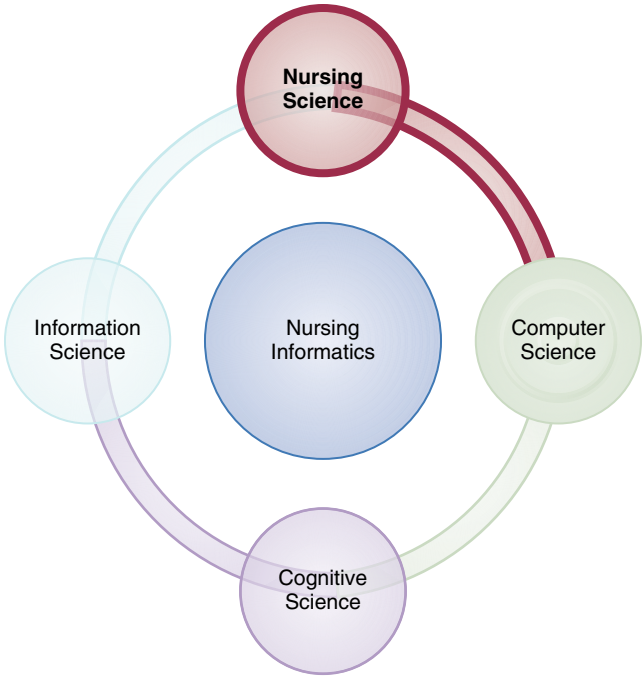

Figure 1-1 Building Blocks of Nursing Informatics

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 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 all 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.

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

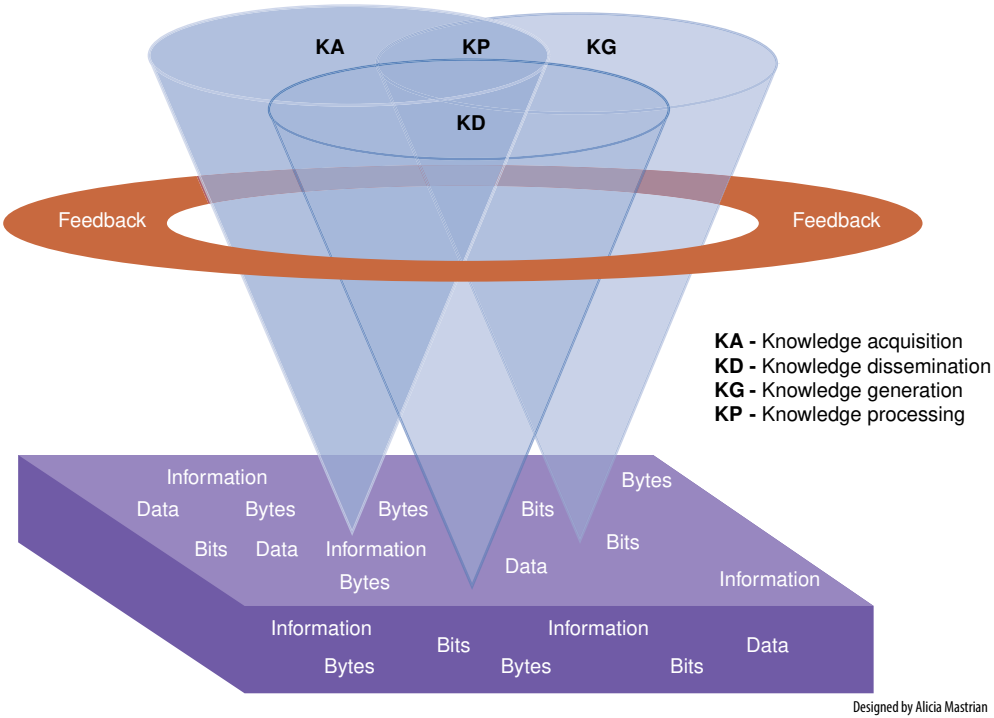

Figure 1-2 Foundation of Knowledge Model

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 is likely to be studied in greater depth as our understanding of professional knowledge increases and processes to capture and codify it improve. 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 remains 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)

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.

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 of 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. More recently introduced in popular literature is the concept of a "learning worker," one who has the ability to learn quickly and continuously (Salisbury, 2017), a designation that may surface more frequently as healthcare organizations transition 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

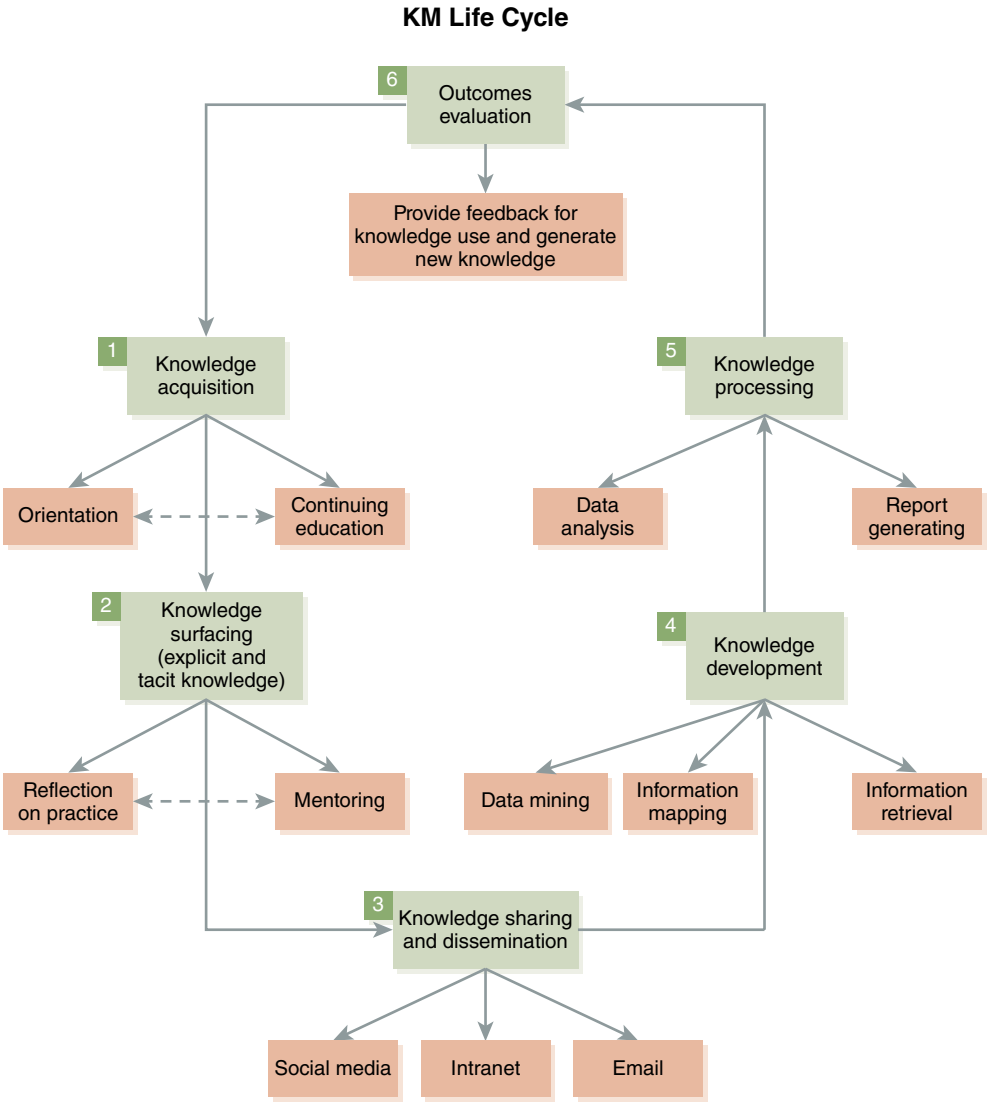

Figure 1-3 The Knowledge Management Life Cycle

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 file away 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 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; intuitions; 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 cocreation of knowledge are beginning to surface in the literature. Bagayogo et al. (2014) suggested that knowledge cocreation is

increasingly important to innovation in organizations and that knowledge is cocreated 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).

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 his or her 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 is able to 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 are able to answer questions, craft theories, find solutions to nursing problems or concerns, and innovate as part of their practice.

Dixon (2012) blogged about knowledge work and knowledge workers and provided these insights:

- Knowledge workers need to acquire new knowledge every 4–5 years or else they become obsolete (para. 4).
- Knowledge work is invisible, interdependent, and constantly changing (para. 5).
- Knowledge workers, whether they are scientists, engineers, marketers, accountants, or administrators, must continuously read the situation in front of them and then, based on that interpretation, determine the appropriate next action to take (para. 5).
- Knowledge workers view their knowledge as their personal possession. The knowledge they possess is in their minds so when they leave the organization, the means of production leaves with them (para. 6).

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 of the 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 physiologic 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. As early as 2000, Goossen reflected on the need for research in this area and believed that the focus of 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 developers, 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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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

CHAPTER 2

Introduction to Information, Information Science, and Information Systems

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.

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 public and private sector stakeholders on a wide-ranging variety of healthcare information solutions. Some of these 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 (Goldstein et al., 2007). 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

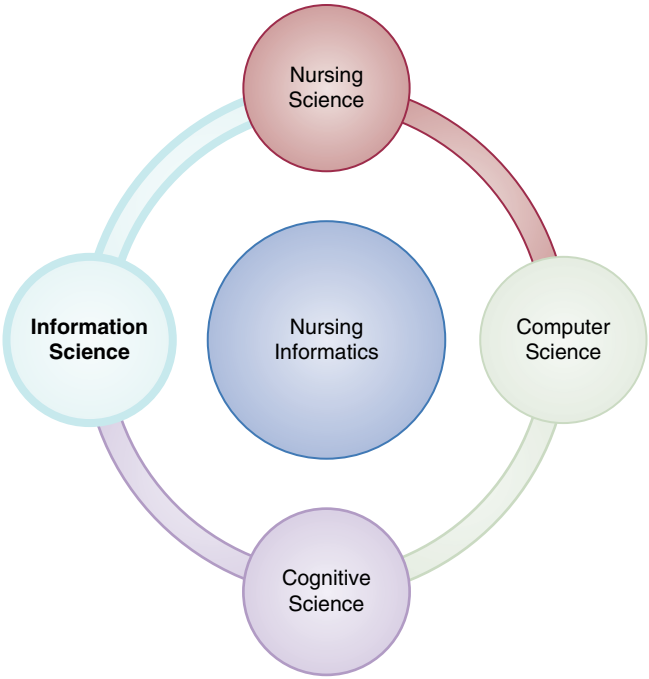

Figure 2-1 Building Blocks of Nursing Informatics

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 to 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 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.

To be valuable and meaningful, information must be of good quality. Its value relates directly to how the information informs decision-making. Characteristics of

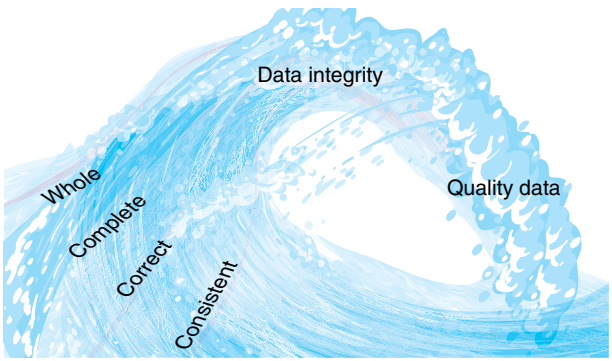

Figure 2-2 Data Integrity

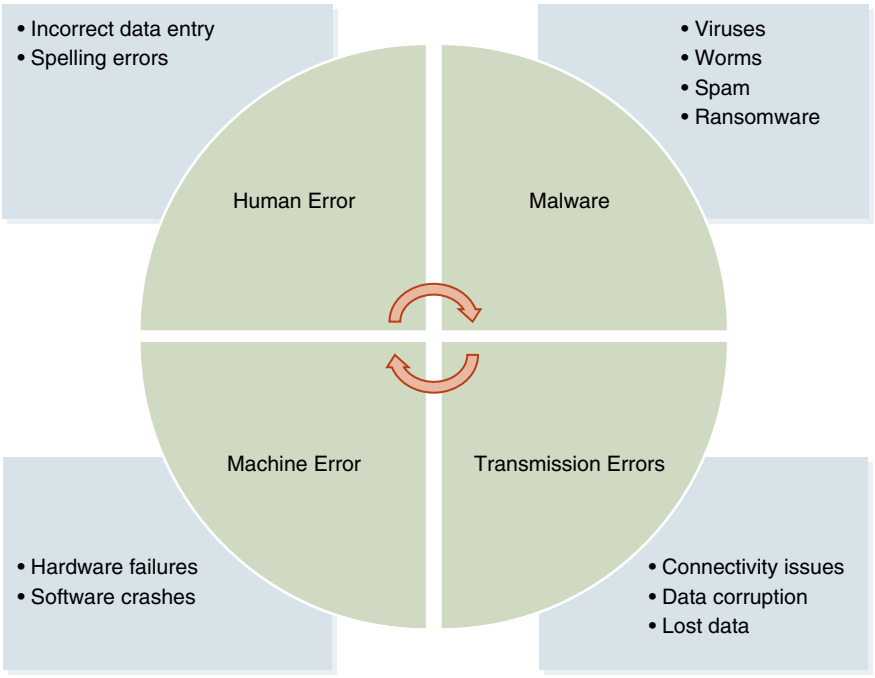

Figure 2-3 Threats to Data Integrity

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. 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 he or she has 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 of 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 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 nor 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 he or she is stating is objective or tainted by his or her 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 of 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 his or her 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 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 focuses 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 impacts 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 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 so as 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 impacts information interfaces and influences how people interact with information and subsequently develop and use knowledge. The information a person acquires is added to his or her knowledge base. 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.

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 impact on information have also influenced how people acquire and use knowledge.

Information science has already had a tremendous impact 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 had to have learned 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 actually 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 integrated ISs that can 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

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 as well as including 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.

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.

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 are also 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). 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 input into them. The capability of the ISs to disseminate, provide feedback, and adjust the data and information, based on these dynamic processes, is what sets them apart. The ISs should be user-friendly entities that provide the right information at the right time and in the right place.

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. According to Schupak (2005), the bunny chip could save the pharmaceutical industry money while sparing "millions of furry creatures, with a chip that mimics a living organism" (para. 1). The HμREL Corporation has developed environments, or biological ISs, that reside on chips and actually mimic the functioning of the human body. Researchers can use these environments to test for both the harmful and 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 physiologic 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 physiologic events. The cell types used may be derived from either standard cell culture lines or primary tissues (https://hurelcorp.com/technology/). In 2019, HμREL and Cyprotex partnered to collaborate and expand their research agendas. As new technologies arise from collaboration and partnerships continue to evolve, more and more robust ISs that can handle a variety of biological and clinical applications will be seen.

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 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 he or she has indeed purchased the movie and is 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. The *Nursing Informatics Practice Applications: Care Delivery* section of 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 raises the bar—enabling connection and communication from anywhere to anywhere—and allows analytics to replace the human decision-maker" (Glaser, 2015, para. 1). Essentially, the sensor-collected data are transmitted to another technology, which triggers an action or an alert that prompts feedback for an action. For example, "imagine a miniaturized, implanted device or skin patch that monitors a diabetic's blood sugar, movement, skin temperature and more, and informs an insulin pump to adjust the dosage" (Glaser, 2015, para. 8). 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.

It is important 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.