SECTION I

Concepts and Issues in Clinical Informatics

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CHAPTER 1
Overview of Informatics in Health Care

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LEARNING OBJECTIVES

1. Review the history of the development of clinical informatics in the United States.
2. Define and discuss key concepts relating to clinical informatics and information science.
3. Describe the present culture of health care in the United States.
4. Describe the role of clinical informatics in contemporary health care in the United States.

KEY TERMS

Clinical informatics
Data (datum)
Communication technologies
Fragmentation
Healthcare providers (HCPs)
Information
Information systems
Knowledge
Nursing informatics (NI)
Wisdom

Chapter Overview

The purposes of this chapter are to provide an overview of health information technology (IT) used in contemporary nursing practice and briefly describe the history of clinical informatics using the culture of health care in the United States as a framework. Clinical informatics can provide possible solutions to existing problems in the U.S. healthcare system including fragmentation, access to care, and care of special populations. Nurses who understand clinical informatics will likely improve healthcare delivery and patient safety.
Informatics in Nursing Practice

The role of the 21st century nurse is complex, requiring interaction with multiple medical devices and health IT. Nurses at all levels of educational preparation and in all healthcare settings use technology every day in practice. In addition to becoming expert users, it is increasingly likely that nurses, because of their rich experience in patient care, will be called on to participate in the design of new clinical systems for delivering high-quality and efficient care. The case study that follows illustrates how technology is integral to all parts of healthcare delivery for healthcare providers (HCPs), patients, and healthcare settings (see BOX 1-1).

**BOX 1-1 Case Study**

Cody arrives for her scheduled 12-hour hospital shift as a circulating surgical registered nurse (RN). After she swipes her name badge at the double doors, the doors slowly swing open for her to proceed to the same-day surgery unit. Another swipe of her badge through the time clock yields a “beep,” and Cody knows her day has officially begun. At the desk, Cody greets her coworkers and glances at the large monitor hanging on the wall in the nurses’ station where the day’s schedule of patients, procedures, their providers, and other notes are posted.

The day’s first case is a tonsillectomy for a 3-year-old boy. Proceeding to the child’s room, she introduces herself to the little boy and his parents and begins preparations needed for the surgical procedure. After scanning the child’s barcoded wrist band and barcodes on the admission paperwork, Cody transmits the codes to the patient’s gurney, so that the staff can track the patient’s movement throughout the surgical suite and recovery area. She offers additional wristbands to the parents. These wristbands are coded to allow movement in and out of the same-day surgical unit and have a unique six-digit identification number that will allow the parents to watch their son’s progress through pre-op, the operating room (OR), and recovery, without breaching privacy rules.

She begins to interview the parents about the child’s health and family history and to reconcile the child’s medications with the computerized list. Once completed, she uses the computer’s touch screen to notify anesthesia services that the patient is ready for the anesthesiologist’s exam.

After the anesthesiologist enters the room and introduces herself, she scans the child’s wristband, comparing it with the barcoded anesthesia assessments and surgical consent she has collected. Once she has completed her interview and examination, she taps a button on the computer screen in the patient’s room, notifying the OR staff that the patient is ready for the surgical procedure. Thirty minutes later, the patient’s name begins to blink on the screen, letting the staff and the parents know that the patient will soon be moved to the OR suite.

At the patient’s bedside, the transport staff and anesthesitist once again compare the code on the child’s wristband with their coded documents, confirming the child’s name and date of birth verbally with the parents. Releasing the brakes on the patient’s gurney, they slowly move the patient to the OR, followed by the child’s parents. Along the way, the transport staff points out the location of large monitor screens on which the parents can track their child’s progress as they wait for the procedure to conclude. As the child’s gurney moves into the OR, a transponder that is embedded in the gurney is detected by a scanner immediately inside the OR door. This information on the patient’s location is imported directly into the electronic health record (EHR) and used to update the monitor in the nurses’ station. In the OR, the patient is transferred to the OR table, which is again synchronized with barcodes on the wristband and documents, as the OR staff comfort the patient. The anesthesiologist begins her work, and as the child sleeps, he is intubated, intravenous access is obtained, and the surgery begins.
History of Clinical Informatics Development

In the 21st century, it is difficult to imagine providing patient care in any setting without the use of computer technology. It is surprising that the word “computer” can be traced to 1646, meaning “one who computes” (Merriam-Webster, 2013). In the 19th century, the word “computer” was used to describe the activities of humans who labored to create tables of numerical values used in science, mathematics, and engineering. Despite painstaking work, the tables contained a high rate of errors, a phenomenon recognized by Charles Babbage, an English mathematician and scholar. In 1821, Babbage began construction of the first mechanical computer, known as the “Analytical Engine” (The Great Idea Finder, 1997–2007), designed to compute the values of polynomial functions, which eventually earned him the title of “Father of Computing” (Hyman, 1982). Babbage’s colleague, Augusta Ada Lovelace (Countess Lovelace), a mathematician, is attributed with the first efforts at programming a computer when she authored the first algorithm intended to be processed by a computer (San Diego Computer Science Center, 1997). Though the Analytical Engine did not have the capability for practical daily use, it possessed many features found in modern computers such as the ability to read data from punch cards, store data, and perform arithmetic operations (The Great Idea Finder, 1997–2007). The Analytical Engine helped users begin to understand the potential value of more sophisticated means of collecting and using data.

Over time, the value of computers and technology in the collection and manipulation of data became readily apparent. Through its work in establishing and maintaining ongoing population records, the United States (U.S.) Census Bureau recognized the ability of digital computers to process large amounts of information. The Universal Automatic Computer (UNIVAC) was designed especially for the Census Bureau’s needs (see FIGURE 1-1). The first version of UNIVAC (UNIVAC I) was used to conduct a portion of the population census in 1950 and then the entire economic census in 1954 (U.S. Census Bureau, n.d.). UNIVAC is widely viewed as the first successful civilian computer, ushering in the dawn of the computer age in information processing.

Although a full history of the development of computers into the handheld models we use today is not within the scope of this text, a brief review of significant changes in the use of computers and technology in health care is
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![UNIVAC 1105](Figure 1-1) A UNIVAC 1105 used in the 1960 census, at the Census Bureau. Courtesy of U.S. Census Bureau. Retrieved from [http://www.census.gov/history/www/innovations/technology/univac_i.html](http://www.census.gov/history/www/innovations/technology/univac_i.html)

specialty field developed by those with interests in manipulation and application of data to patient care. Data storage and maintenance are also of interest to the federal government because huge databases containing billions of data points on patients are available for researchers to answer clinical questions.

A review of the history of clinical informatics would not be complete without a discussion of nursing’s contribution to the field and to the development of nursing informatics (NI) as a science in the public and private sectors. In the late 1950s, Harriet Werley became the first nurse researcher at the Walter Reed Army Research Institute and was asked to join a small group of people who were consulting about the possibilities of using computers in health care. Werley was instrumental in promoting research on what would later emerge as the field of NI (Ozbolt & Saba, 2008).

The American Medical Informatics Association (AMIA) recognizes many important nurse leaders as NI pioneers. While this text cannot highlight all, it is important to understand the contributions that have shaped the discipline of NI.

Dr. Patricia Abbott, who might be best known for her work in helping to develop NI as a specialty field, was a member of the team of authors who crafted the initial American Nurses Association Scope and Standards of Practice for Nursing Informatics (AMIA, n.d.). Dr. Abbott also worked with the American Nurses Credentialing Center to develop the first certification exam in NI. Dr. Virginia Saba, another pioneer of NI, actively participated in initiating academic technology programs and healthcare IT systems (AMIA, n.d.). Dr. Saba has coordinated distance learning projects for nurses and served on national healthcare standards committees. Dr. Kathleen McCormick has been a clinical trial researcher and NI scientist within the National Institutes of Health Clinical Center and the National Institute on Aging, and she is an elected member of the National Academy of Sciences, Institute of Medicine (IOM) now called the National Academy of Medicine (AMIA, n.d.).

Activities of NI pioneers are not limited to the field of nursing. Dr. Marion Ball has provided...
service to the public sector as a member of the National Academy of Medicine and on the Board of Regents of the National Library of Medicine (AMIA, n.d.). She has worked with multiple national and international committees, including serving as president of the International Medical Informatics Association and as a board member of the AMIA. Dr. Ball was also invited to serve as an international advisor to the Board of the China Hospital Information Management Association. Roy L. Simpson, vice president, NI, Cerner Corporation, worked with colleagues to develop the Nursing Minimum Data Set and to develop online nursing administration and NI master’s programs (AMIA, n.d.).

NI pioneers are also active in the areas of educating and fostering the NI workforce of tomorrow. Dr. Linda Thede is professor emeritus at the College of Nursing at Kent State University, where she has developed and taught NI programs (AMIA, n.d.). Dr. Susan K. Newbold, a healthcare informatics consultant based in Franklin, Tennessee, worked to found CARING, an NI group that was established in 1982. She also participates in teaching NI to nursing students at multiple curricular levels (AMIA, n.d.). Dr. Susan J. Grobe developed the Nursing Education Module Authoring System, which consists of a set of software programs that faculty can use to create modules on the nursing process. Dr. Grobe was one of the first of two nurse fellows elected to the American College of Medical Informatics (AMIA, n.d.).

Clinical informatics is a broad term that encompasses all medical and health specialties, including nursing, and addresses the ways information systems (e.g., EHRs, barcode medication administration systems, radiology imaging system, and patient-care devices) are used in the day-to-day operations of patient-care. The domains of clinical informatics include health systems, clinical care, and information and communication technologies (see Figure 1-2).

The purpose of clinical informatics is to improve patient care by using methods and technologies from established disciplines such as computer science and information science.

Nursing informatics is a specialty in the discipline of nursing, and it is classified as a special interest group in professional organizations whose focus is clinical informatics. NI is defined by the International Medical Informatics Association’s Nursing Informatics Special Interest Group (2009) as the “science and practice [that] integrates nursing, its information and knowledge, with management of information and communication technologies to promote the health of people, families, and communities worldwide.” Because of the emphasis on promoting health, the study of NI is a natural fit for nurses who are dedicated to quality care for patients. As described in this book, the understanding of NI concepts is not a “nice to know” set of knowledge, skills, and values; rather, it is a requirement for effective nursing practice (Thede, 2012).

**Clinical Informatics and Nursing Informatics Defined**

Clinical informatics is a broad term that encompasses all medical and health specialties, including nursing, and addresses the ways information systems (e.g., EHRs, barcode medication administration systems, radiology imaging system, and patient-care devices) are used in the day-to-day operations of patient-care. The domains of clinical informatics include health systems, clinical care, and information and communication technologies (see **Figure 1-2**).

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**Figure 1-2** Domains of clinical informatics.

The role of clinical informatics is becoming increasingly important and can be seen in almost every aspect of patient care, from the bedside to the patient’s bill. The use of powerful clinical informatics tools can support processes of care, such as promoting the flow of information between those who are involved in the delivery of care across HCPs in large delivery systems. At the macro-system level, clinical informatics tools can be used to assess specific outcomes of care for groups, such as the efficacy of annual influenza vaccinations or fall prevention programs.

### Clinical Informatics Concepts

Informatics is a multidisciplinary science, with its beginnings in how data are processed and communicated between systems. What are data? Data are values or measurements, bits of information that can be collected and transformed, allowing a person to answer a question or to create an end product, such as an image. In health care, data may be created with every patient encounter. Nurses and other HCPs use their education and experience to assemble data in a clinical context to create information, which gives insight about patient care. Information can then be used to plan care for patient aggregates, increase the efficiency of organizations, improve quality of care, prevent medical errors, increase efficiency of care, and potentially reduce unnecessary costs. Knowledge creation concerns the ways that nurses and HCPs use the data and information they create to better understand and manage their practice. Graves and Corcoran provided a classic definition of knowledge as “relationships are identified and formalized” (1989, p. 230). For example, information is a trend of a patient’s vital signs and lab results after surgery, and knowledge is recognition that elevation in a patient’s temperature and white blood cell count could mean a post–operative infection is developing. The proper use of knowledge to solve real-world problems and aid continuous improvement is what is known as wisdom (McGonigle & Mastrian, 2012).

Many different systems support the movement from data to information, information to knowledge, or knowledge to wisdom. Systems that support the transition from data to information are known as information systems. Systems that support the transition from information to knowledge are decision-support systems, and those that apply knowledge through wisdom are known as expert systems (McGonigle & Mastrian, 2012). At each level, these systems contain computer, communications, and human elements.

Principles of informatics can apply to many different fields, from economics to health care. However, in clinical informatics, people with a background in health care use informatics tools, such as health information databases, medical imaging software, or point-of-care technologies to capture information and present it to other members of healthcare teams. The implementation of clinical informatics tools has the potential to create vast improvements in patient care by improving efficiency and reducing errors, which is a top priority for the United States.

### The Culture of Health Care in the United States

The United States spends more per capita on health care than any other country in the world. Health expenditures in the United States neared $3.2 trillion in 2015—accounting for 17.8% of the overall share of the economy (Centers for Medicaid and Medicare Services [CMS], Office of the Actuary, National Health Statistics Group, 2015). While the intent of the Affordable Care Act (ACA), enacted in 2010, was to reduce healthcare spending, the ACA is typically associated with the expansion of health care to underserved individuals. Though cost containment has been demonstrated in areas of health care,
costs continue to rise at a rate of 5.4% annually through 2024 (Altarum Institute, 2017).

Despite continued increases in healthcare spending, a public opinion poll on the quality of health care in the United States would yield a variety of responses. A report from the IOM (2011) draws attention to the poor health of U.S. citizens. Though the United States has the highest rate of per capita spending on health care, comparing our population of citizens under the age of 75 to those of peer countries finds that ours have higher rates of chronic diseases and disabilities (IOM, 2011). According to the Commonwealth Fund, the United States ranks poorly, and frequently last, when compared with 11 other industrialized countries on factors of health care including healthy lives, access to care, healthcare quality, efficiency, and equity (The Commonwealth Fund, 2014). On measures of quality, the United States ranks near the top in two of four aspects of quality, effective care, and patient-centered care, but ranks much lower in providing safe and coordinated care (2014). Fragmentation, occurring when healthcare professionals focus on momentary issues with patients and failing to look at the “big picture” is a serious issue in today’s healthcare environment.

The Impact of Fragmentation

Missing medical information can be a detriment to care in many settings, but perhaps more so in areas of high acuity, in which HCPs may be forced to make rapid decisions that may be challenging to patient safety. A retrospective review of 3.6 million patient visits to acute care sites in Massachusetts from 2002 to 2007 revealed that 56.5% of the patients were multisite users or had used more than one acute care site within the 5-year period (Bourgeois, Olson, & Mandl, 2010). Fragmentation of care ultimately places patients at greater risk for poor outcomes, particularly if those patients have multiple or chronic conditions. Patients with chronic diseases such as type 2 diabetes mellitus (T2DM) are at risk for multiple complications that often necessitate management by subspecialists such as ophthalmologists, nephrologists, podiatrists, and cardiologists. Initiating such referrals and follow-ups for patients with T2DM, while consistent with evidence-based guidelines, can be an arduous task for an HCP. Patients who do not receive needed referrals for treatment of complications may be forced to seek care in settings that are more expensive and less appropriate for chronic management, such as an emergency department (ED). Liu, Einstadter, and Cebul (2010) studied the effects of care fragmentation on a group of 683 adult patients with diabetes and chronic kidney disease. The primary outcome variable was the number of ED visits made during a 2-year period. Findings from the study revealed that patients who had fewer visits to primary HCPs had higher numbers of ED visits.

For optimal protection against transmissible diseases such as measles, mumps, and pertussis, childhood immunizations must be given at specified intervals and ages. Tracking the administration of childhood immunizations for each child, which may total 24 timed vaccinations during the first 18 months of life, is another area at risk for fragmentation and subsequent elevation in risk of acquiring childhood diseases (Centers for Disease Control and Prevention [CDC], 2013). The effects of fragmented health care have also been studied in immunization rates of children aged 19–35 months residing in four geographical areas (northern Manhattan, San Diego, Detroit, and rural Colorado), which have received federal designation as health professional shortage areas (Yusuf et al., 2002). HCPs must have reliable information in order to offer necessary immunizations; otherwise children may miss opportunities for vaccinations if providers decide to delay based on inaccurate or incomplete records from parents or other HCPs. Incomplete information from recent HCPs was associated with both overimmunization and underimmunization in this study (Yusuf et al., 2002). The utilization of community-wide immunization registries, containing information from all immunization providers in a community, was suggested as a solution to the dilemma.
of clinical questions regarding vaccinations (Yusuf et al., 2002).

Inaccurate or incomplete transfer of information, another example of the fragmentation that permeates health care today, can put vulnerable patients at risk of adverse events, hospital readmission, and even death in the transition from inpatient to home care (Davis, Depoe, Kansagara, Nicolaides, & Englander, 2012). HCPs have identified the need for improved communication between healthcare systems, particularly for those patients who have conditions that have been identified as high risk for hospital readmission. In a qualitative study of 75 healthcare professionals, representing physicians, nurses, pharmacists, and other allied health professionals, poor cross-site communication was noted as a major gap in helping patients to transition from hospital to home (Davis et al., 2012). These gaps were amplified by the lack of interoperability between EHR systems of the facility and outpatient practice, and this was especially troubling to primary care providers who cited:

A patient's there in front of me [after discharge], they've had a life changing event, and I'm sitting there without the information. You feel like an idiot. . . . I would think, "What kind of system do you guys have here? I almost died, and you don't even have the information." . . . That's embarrassing and I don't think it engenders a lot of confidence for your patients. (Davis et al., 2012, p. 1653)

Introduction

Introducing Information Science

The Promises of Clinical Informatics Systems

The adoption of clinical informatics systems has the potential to address issues of fragmentation by integrating healthcare delivery across groups of HCPs, health systems, and insurers. The full potential of clinical informatics tools remains to be realized. Improving efficiency of care for specific disease states, care settings, and populations is an area in which clinical informatics tools can make a positive impact. For example, a survey of 40 hospital infection preventionists suggests that expansion of the hospital EHR's capabilities, in order to provide clinical decision prompts on patients who need closer inspection, would be of benefit in detecting and providing timely care for patients with hospital-associated infections. Improved awareness of regional health initiatives and public health reporting capabilities would increase communication and earlier detection (McKinney, 2013).

Improved Efficiency

Defragmentation, a strategy long used in fields such as engineering, computer science, and manufacturing, is a means of managing limited resources while improving the performance of a system. A myriad of applications for health IT and informatics systems incorporating defragmentation can be used to improve efficiency, even in the office environment, where millions of patients schedule appointments with HCPs every day. Conventional appointment scheduling, in which a block of time is scheduled to accommodate a patient's needs, is a trade-off between the need to maximize the productivity of an HCP while minimizing the wait time for a patient. A ranked list of most preferred to least preferred appointment time slots for providers was created for schedulers, designed to offer guidance on how to best schedule patient appointments to prevent provider schedule fragmentation (Lian, Distefano, Shields, Heinichen, Giampietri, & Wang, 2010). A computer model was developed to measure efficiency using two metrics: "acceptance rate (the number between the number of accepted appointments and the total number of appointment requests), and the utilization rate (the health care provider's
actual service time divided by the total work time)” (Lian et al., 2010, p. 128). The advanced appointment scheduling process was tested in four different specialty and primary care clinics. The aggregation of open time slots for HCPs that resulted from the implementation of the process was utilized in various ways, including the addition of new patient appointments in the open blocks of time.

Improving the Health Care of Older Adults

Older adults bear a higher burden of illness and frailty, and may transition frequently between healthcare systems, leading to both increased economic costs and physical risk. More than 125 million Americans had at least one chronic disease diagnosis in 2000, and this number is expected to grow to 157 million by the year 2020 (Wu & Green, 2000). A disproportionately large number of older adults are dealing with chronic illnesses. Potentially avoidable hospitalizations in older adult clients often result in poor outcomes, which are unnecessary and create excessive expenditures. By improving communication across systems, clinical informatics may assist HCPs in meeting the challenges of caring for older adults. For example, the Regenstrief Medical Record System (RMRS), housed at the University of Indiana and serving the Indianapolis area, contains records from more than 1.3 million patients. As early as 1974, the RMRS began to deliver automatic reminders in the form of paper reports, creating reminders for preventive services such as fecal occult blood testing, mammography, and vaccinations—topics pertinent to the care of older adults. In a 2-year randomized trial involving 130 providers and more than 12,000 patients, investigators found that older adult patients of physicians who received reminders for influenza vaccinations were twice as likely to receive the vaccination as patients of physicians who did not receive electronically generated reminders (Weiner et al., 2003).

Challenges in Clinical Informatics

Clinical informatics technologies have multiple purposes—to improve health of people, aggregates, communities, and populations. However, several barriers must be overcome if technology can really improve the U.S. healthcare system. The first and biggest barrier is the lack of system interoperability, which restricts the flow of data from one information system to others (Thede, 2012). There are many reasons for the interoperability problem, including the purchase of “best of breed” systems for specialty practices, the use of legacy systems that cost too much to upgrade, and integration processes that are too difficult to implement. Poor usability of health IT is the second barrier (Thede, 2012). When nurses and other HCPs are burdened with technology rather than helped by it, the health IT has been improperly designed for the user experience and for the workflow. A related and important third barrier is the failure to design health IT for human factors to prevent errors (Thede, 2012). The interaction of humans with technology is studied in other fields and applied in the design of technology and processes. In clinical informatics, attention to human factors is emerging and will become more prominent as a strategy to improve patient safety.

The Role of the Nurse

Nurses will play key roles in the redesign of healthcare delivery systems, with expanded roles, knowledge, and skill sets, to address problems facing the health IT world, such as lack of interoperability. The challenges of working with specific populations, complex comorbidities, and multiple healthcare systems, along with the increasing need to incorporate evidence-based practice make it necessary for nurses at all levels of educational preparation to master essential informatics competencies. In addition to familiarity with basic computer skills, nurses will need proficiency with patient-care technologies...
and “an attitude of openness to innovation and continual learning, as information systems and patient care technologies are constantly changing” (American Association of the Colleges of Nursing, 2008, p. 19).

Bridging the Gap Between Development and Clinical Use

With their experience in multiple aspects of patient care, nurses have the capacity to be far more than end users. Participating in the design, testing, and launch of informatics technologies can help to increase the accuracy, ease of use, and adoption of valuable tools, such as the EHR. Previous studies have reported an 83% increase in the success of entry of history of present illness and review of systems data into an electronic chart when the task was assigned to a nurse (EHR Intelligence, 2012). Nurses have often found themselves serving as translators for patients, families, and other healthcare professionals. Many nurses will find a natural extension of this talent in their work with assisting other HCPs to efficiently use health IT technologies.

Summary

HCPs recognized the impact of informatics to improve outcomes for patients more than 100 years ago. New applications for informatics-based tools continue to emerge, offering nurses and other HCPs a valuable mechanism of improving delivery and outcomes of care for patients. While not every nurse will require more formal education in informatics, every nurse must realize that health IT technology is simply another tool to be used in nursing care. As nursing students acquire familiarity with technically complex tasks such as gaining intravenous access or inserting Foley catheters, it is reasonable to include the attainment of familiarity with health IT technologies as an expectation. Understanding informatics concepts, which is the basis for development of sophisticated health IT tools, will provide a groundwork for nurses to develop their skills in a growing aspect of health care.

References


References


