

SECTION I

Concepts and Issues in Clinical Informatics

CHAPTER 1

Overview of Informatics in Health Care

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CHAPTER 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)

Fragmentation

Healthcare providers (HCPs)

Information

Knowledge

Nursing informatics

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. 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 upon 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. “It’s going to be another busy day,” she thinks to herself. Cody finds the patient, Mr. Jones, who she is scheduled to move from preop to the operating room (OR) suite, noting that he is to undergo a robotic prostatectomy. She picks up a clipboard and touches the screen. The patient’s name begins to blink, letting other staff know that the patient will soon be in the OR suite.

At the patient’s bedside, Cody introduces herself to the patient and the family and notes the planned surgery. She uses a bar-code scanner on the patient’s bracelet, and she notes the completed consent documents on her electronic clipboard. Releasing the brakes on the patient’s gurney, Cody and Mr. Jones bid farewell to his family members, and they move slowly down the hall to the OR. As Mr. Jones’ 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 is both imported directly into the electronic health record (EHR) and used to update the monitor in the nurses’ station. In the OR, she assists with transferring the patient to the OR table and positions him comfortably. The anesthesiologist places a mask over the patient’s face and, after full anesthesia is achieved, the surgery begins.

Less than 4 hours later, the surgery is complete, and Cody assists in moving Mr. Jones back to the gurney for transfer to the post-anesthesia care unit (PACU). As the gurney moves through the door of the suite, the scanner again detects the transponder, updating the EHR and notifying the PACU that the patient is on his way. In the PACU, Mr. Jones’ vital signs, oxygen saturation, and heart rhythm will be monitored until he awakens. Once he is stable, Mr. Jones can be moved to his room on the medical-surgical unit.

After an uncomplicated postoperative recovery period, Mr. Jones is ready to be discharged. As Mr. Jones’ surgeon and nurse practitioner perform morning rounds, they prepare Mr. Jones for discharge. The nurse on the medical-surgical unit confirms that Mr. Jones’ discharge medications are reconciled with his prescriptions for pain medications and electronically transmitted from the EHR to the pharmacy. As the unit nurse completes her discharge teaching for Mr. Jones and his family, further instructions are printed. A follow-up appointment request is faxed to the surgeon’s office from the EHR.

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 (Merriam-Webster, 2013). The word “computer” literally means “one who computes.” 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” (<http://www.charlesbabbage.net/>). 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 was the conceptual and technical basis for the highly developed technology in use today.

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 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 needs of the Census Bureau (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.

While a full history of the development of computers into the hand-held 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 warranted. Robert Ledley, a dentist who also studied physics, is credited with invention of the first full-body computed tomography (CT) scanner. Dr. Ledley had a deep interest in how the fields of pattern recognition and image analysis could be applied to patient care through the use of computers and founded the National Biomedical Research Foundation in 1960, a nonprofit organization dedicated to the promotion of computing methods among biomedical scientists. He was also a founding fellow of the American College of Medical Informatics. Dr. Ledley foresaw the role of technology in issues of patient

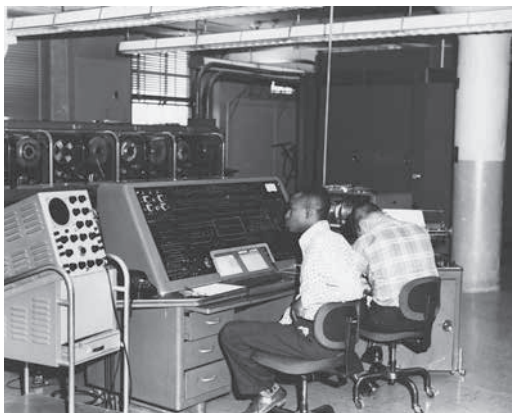


FIGURE 1-1 Photo of UNIVAC 1105 used in the 1960 census, at Census Bureau.

Source: http://www.census.gov/history/www/innovations/technology/univac_i.html

care such as recordkeeping, imaging, and diagnosis in settings ranging from private office practices to acute care facilities. Today, the use of technologically driven devices such as electrocardiogram machines, ventilators, and intravenous pumps necessitates a degree of technical skill in every clinician.

The increasing incorporation of technology into health care quickly resulted in an accumulation of data as HCPs realized that not only could computers be used at the point of patient care, but they also could collect and store data useful for later patient care. Specialty fields, developed by people with interest in data manipulation and its application, arose from this need to maintain and apply analysis of data to patient care. The field of clinical informatics is an example. 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 (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 Institute 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, TN, 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 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 are used in the day-to-day operations of patient care. The domains of clinical informatics include

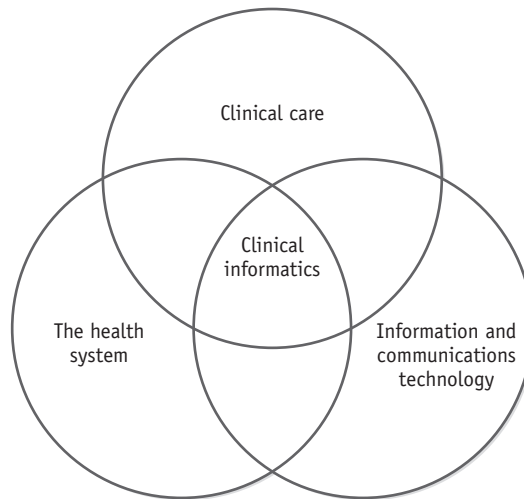


FIGURE 1-2 Domains of clinical informatics.

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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 subsequent chapters, 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).

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. Use of powerful clinical informatics tools can be used to 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 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 one to answer a question or to create an end product, such as an image. Data are created with every patient contact. 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. 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 transfer 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.

HEALTH CARE IN THE UNITED STATES AND THE NEED FOR HEALTH INFORMATION MANAGEMENT

The United States spends more per capita on health care than any other country in the world. Health expenditures in the United States neared \$2.6 trillion in 2010—more than 10 times the \$256 billion spent in 1980, and costs are increasing annually

(Centers for Medicaid and Medicare Services [CMS], 2012). Despite the spending, a poll of public opinion on the present culture of health care in the United States would garner a variety of responses. While there are those who would express satisfaction, it is far more likely that more people would be unhappy about some aspect of the healthcare environment. This growing dissatisfaction has attracted attention. A recent report from the Institute of Medicine (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). In a country with as many assets as the United States, particularly in the field of health care, how can this be the case? More importantly, what tools and strategies exist that can potentially change this situation?

Burden 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 2002–2007 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 to 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, Devoe, Kansagara, Nicolaidis, & 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)

The Promises of Clinical Informatics Systems

The adoption of clinical informatics systems has the potential to improve many of the issues troubling health care today in the United States, yet 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 capabilities of the hospital EHR, 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 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 the needs of a patient, is a tradeoff 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 higher costs and risk. More than 125 million Americans had at least one chronic disease 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 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

A key concept in clinical informatics is the purpose of the IT—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.

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 ways to decrease fragmentation of care in their own

settings. As informatics tools continue to be adapted for the field of health care, nurses will play an integral role in analysis, planning, and implementing ways health IT can be used to improve patient care.



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