Introduction

Technology surrounds us! Intravenous pumps are “smart,” biomedical monitoring is no longer exclusively an intensive care practice, and computers are used at the bank, at the grocery checkout, in our cars, and in almost every other aspect of daily living, including the provision of health care. Health care is both a technology and an information intensive business; therefore the success of nurses using biomedical technology, information technology (IT), and knowledge technology will contribute to their personal and professional development and career achievement.

Although information technology abounds in the nursing workplace, students and nurses may not perceive that they are receiving sufficient education about its application in health care, though they report an overall positive attitude toward technology. The Quality and Safety Education for Nurses (QSEN) project identified informatics competency as a necessary component of the knowledge, skills, and attitudes necessary to continuously improve the quality and safety of health care (Cronenwett et al., 2009). Nurses will likely be able to use information and technology to communicate, manage knowledge, mitigate error, and support decision making (AACN, 2012).

The TIGER Initiative, an acronym for **T**echnology **I**nformatics **G**uiding **E**ducation **R**eform, was formed in 2004 to bring together nursing stakeholders to develop a shared vision, strategies, and specific actions for improving nursing practice, education, and the delivery of patient care through the use of health information technology. The TIGER Informatics Competencies Collaborative (TICC) Team was formed to develop informatics recommendations for all practicing nurses and graduating nursing students. The Team created the TIGER Nursing Informatics Competencies Model, which has three parts:

1. Basic computer competencies

2. Information literacy

3. Information management

Details of each can be found at The Tiger Initiative (2010): *www.tigersummit.com/uploads/3.Tiger.Report\_Competencies\_final.pdf*.

In the hospital of the future, technology will be the foundation of patient care planning, organization, and delivery (Parker, 2005). Many leaders in health care see technology as a means to facilitate decision making, improve efficacy and efficiency, enhance patient safety and quality, and decrease healthcare costs (Ball, Weaver, & Abbot, 2003; Institute of Medicine [IOM], 2000, 2001, 2004, 2011). If appropriately implemented and fully integrated, technology has the potential to improve the practice environment for nurses, as well as for patients and their families. However, we are also cautioned by patient safety and quality experts that technology is not a panacea (IOM, 2004, 2011).

Good decision making for patient care requires good information. Nurses are **knowledge workers**, who need **data** and **information** to provide effective and efficient patient care. Knowledge work is not routine or repetitive but, instead, requires considerable cognitive activity and critical thinking (Drucker, 1993). Data and information must be accurate, reliable, and presented in an actionable form. Technology can facilitate and extend nurses’ decision-making abilities and support nurses in the following areas: (1) storing clinical data, (2) translating clinical data into information, (3) linking clinical data and domain knowledge, and (4) aggregating clinical data (Snyder-Halpern, Corcoran-Perry, & Narayan, 2001).

Types of Technologies

As nurses, we commonly use and manage three types of technologies: biomedical technology, information technology, and knowledge technology. **Biomedical technology** involves the use of equipment in the clinical setting for diagnosis, physiologic monitoring, testing, or administering therapies to patients. **Information technology** entails recording, processing, and using data and information for the purpose of delivering and documenting patient care. **Knowledge technology** is the use of expert systems to assist clinicians to make decisions about patient care. In nursing, these systems are designed to mimic the reasoning of nurse experts in making patient care decisions.

Biomedical Technology

Biomedical technology is used for (1) physiologic monitoring, (2) diagnostic testing, (3) intravenous fluid and medication dispensing and administration, and (4) therapeutic treatments.

Physiologic Monitoring

Physiologic monitoring systems measure heart rate, blood pressure, and other vital signs. They also monitor cardiac rhythm; measure and record central venous, pulmonary wedge, intracranial, and intra-abdominal pressures; and analyze oxygen and carbon dioxide levels in the blood.

Data about adverse events in hospitalized patients indicate that a majority of physiologic abnormalities are not detected early enough to prevent the event, even when some of the abnormalities are present for hours before the event occurs (Considine & Botti, 2004; Akre et al., 2010). Patient surveillance systems are designed to provide early warning of a possible impending adverse event. One example is a system that provides wireless monitoring of heart rate, respiratory rate, and attempts by a patient at risk for falling to get out of bed unassisted; this monitoring is via a mattress coverlet and bedside monitor.

Innovative technology permits physiologic monitoring and patient surveillance by expert clinicians who may be distant from the patient. The remote or virtual intensive care unit (vICU) is staffed by a dedicated team of experienced critical care nurses, physicians, and pharmacists who use state-of-the-art technology to leverage their expertise and knowledge over a large group of patients in multiple intensive care units (Breslow, 2007; Myers & Reed, 2008).

Intracranial pressure (ICP) monitoring systems monitor the cranial pressure in critically ill patients with closed head injuries or postoperative craniotomy patients. The ICP, along with the mean arterial blood pressure, can be used to calculate perfusion pressure. This allows assessment and early therapy as changes occur. When the ICP exceeds a set pressure, some systems allow ventricular drainage. Similarly, monitoring pressure within the bladder has recently been demonstrated to accurately detect intra-abdominal hypertension while measures of maximal and mean intra-abdominal pressures and abdominal perfusion pressure are made. Intra-abdominal hypertension occurs with abdominal compartment syndrome and other acute abdominal illnesses and has been demonstrated to be independently associated with mortality in these patients (Malbrain et al., 2005; Vidal et al., 2008).

Continuous dysrhythmia monitors and electrocardiograms (EKGs) provide visual representation of electrical activity in the heart and can be used for surveillance and detection of dysrhythmias and for interpretation and diagnosis of the abnormal rhythm. Although not a new technology, these systems have grown increasingly sophisticated. More important, integration with wireless communication technology permits new approaches to triaging alerts to nurses about cardiac rhythm abnormalities. Voice technology and integrated telemetry and nurse paging systems have both been demonstrated to close the communication loop and dramatically decrease response time to dysrhythmia alarms (Bonzheim, 2006).

Biomedical devices for physiologic monitoring can be interfaced with clinical information systems. Monitored vital signs and invasive pressure readings are downloaded directly into the patient’s electronic medical record, where the nurse confirms their accuracy and affirms the data entry.

Diagnostic Testing

Dysrhythmia systems can also be diagnostic. The computer, after processing and analyzing the EKG, generates a report that is confirmed by a trained professional. EKG tracings can be transmitted over telephone lines from remote sites, such as the patient’s home, to the physician’s office or clinic. Patients with implantable pacemakers can have their cardiac activity monitored without leaving home.

Other systems for diagnostic testing include blood gas analyzers, pulmonary function systems, and ICP monitors. Contemporary laboratory medicine is virtually all automated. In addition, point-of-care testing devices extend the laboratory’s testing capabilities to the patient’s bedside or care area. In critical care areas, for example, blood gas, ionized calcium, hemoglobin, and hematocrit values often are measured from unit-based “stat labs.” Point-of-care blood glucose monitors can download results of bedside testing into an automated laboratory results system and the patient’s electronic record. Results can be communicated quickly and trends analyzed throughout patients’ hospital stays and at ongoing ambulatory care visits. Results can calculate the necessary insulin doses based on evidence for tight blood glucose control and evoke electronic orders for administration. This is an example of integrating a diagnostic test result with the appropriate orders-based intervention.

Intravenous Fluid and Medication Administration

Intravenous (IV) fluid and medication distribution and dispensing via automated dispensing cabinets (ADCs) were introduced in the 1980s and are used in a majority of hospitals today. ADCs can decrease the amount of time before a medication is available on patient care units for administration, ensure greater protection of medications (especially controlled substances), and efficiently and accurately capture drug charges. Most importantly, ADCs can reduce the risk of medication errors but only when safeguards are available and used. The Institute for Safe Medication Practices (ISMP) has developed guidelines for safest use of ADCs (ISMP, 2008). The guidelines contain 12 core practices associated with safe ADC use and are available on the ISMP Website (*www.ismp.org/Tools/guidelines/ADC/default.asp*). Some ADC machines have the ability to communicate in real time within the electronic health record (EHR), allowing the nurse to see all patient information at the point of care. This closes the loop in the medication process by having all members of the care team using one single patient file and source of truth.

IV smart pumps are used to deliver fluids, blood and blood products, and medications either continuously or intermittently at rates between 0.01 and 999 mL per hour. Twenty-first century pumps offer safety features, accuracy, advanced pressure monitoring, ease of use, and versatility. These pumps have rate-dependent pressure detection systems, designed to provide an early alert to IV cannula occlusion with real-time display of the patient-side pressure reading in the system. Smart pumps can be programmed to calculate drug doses and medication infusion rates from an internal database or “drug library,” as well as determine the volume and duration of an infusion. Nurses, when programming the smart pump, can receive soft and hard stop alerts to significant programming errors or contradiction based on entered details.

Therapeutic Treatments

Treatments may be administered via implantable infusion pumps that administer medications at a prescribed rate and can be programmed to provide boluses or change doses at set points in time. These pumps are commonly used for hormone regulation, treatment of hypertension, chronic intractable pain, diabetes, venous thrombosis, and cancer chemotherapy.

Therapeutic treatment systems may be used to regulate intake and output, regulate breathing, and assist with the care of the newborn. Intake and output systems are linked to infusion pumps that control arterial pressure, drug therapy, fluid resuscitation, and serum glucose levels. These systems calculate and regulate the IV drip rate.

Increasingly sophisticated mechanical ventilators are used to deliver a prescribed percentage of oxygen and volume of air to the patient’s lungs and to provide a set flow rate, inspiratory-to-expiratory time ratio, and various other complex functions with less trauma to lung tissue than was previously possible. Computer-assisted ventilators are electromechanically controlled by a closed-loop feedback system to analyze and control lung volumes and alveolar gases. Ventilators also provide sophisticated, sensitive alarm systems for patient safety.

In the newborn and intensive care nursery, computers monitor the heart and respiratory rates of the babies there. In addition, newborn nursery systems can regulate the temperature of the infant’s environment by sensing his or her temperature and the air of the surrounding environment. Alarms can be set to notify the nurse when preset physiologic parameters are exceeded. Computerized systems monitor fetal activity before delivery, linking the EKGs of the mother and baby and the pulse oximetry, blood pressure, and respirations of the mother.

Biomedical technology affects nursing as nurses provide direct care to patients treated with new technologies: monitoring data from new devices, administering therapy with new techniques, and evaluating patients’ responses to care and treatment. Nurses must be aware of the latest technologies for monitoring patients’ physiologic status, diagnostic testing, drug administration, and therapeutic treatments. Nurses need to identify the data to be collected, the information that might be gained, and the many ways that these data might be used to provide new knowledge. More importantly, nurses must remember that biomedical technology supplements, but does not replace, the skilled observation, assessment, and evaluation of the patient.

Biomedical technology is designed to help keep patients safe and to alert staff of changes in the patient’s condition. A Sentinel Event Alert from The Joint Commission (2013a) brought attention to alarm fatigue or alarm desensitization from biomedical technology. The overuse of alarms from infusion pumps, feeding devices, monitors, and ventilators can cause sensory strain. Staff who are overwhelmed by the sheer number of alarms can miss or delay responding, leading to sentinel events or even patient death. Desensitization to the alarms is quickly becoming a national problem (Wood, 2013; Pevtzow, 2013; Harrison, 2013).

Nursing leaders must be aware of how these technologies fit into the delivery of patient care and the strategic plan of the organization in which they work.

Patient data displayed with computerized systems to provide meaningful information and trends.



They must have a vision for the future and be ready to suggest solutions that will assist nurses across specialties and settings to improve patient care safety and quality.

Exercise 11-1

List the types of biomedical technology available for patient care in your organization. List ways that you currently use the data and information gathered by these systems. How do these help you care for patients? Can you think of other ways to use the technology? Can you think of other ways to use the data or information? For example, data from biomedical devices might be sent directly to the electronic health record, negating the need for transcription of a result into the patient’s chart. Nurses spend many hours learning to use biomedical devices and to interpret the data gained from them. Have we come to rely too heavily on technology rather than on our own judgment? You might consider using your computer skills to draw a concept map to illustrate the relationships between the types of biomedical, diagnostic, therapeutic, and information technologies available in healthcare organizations you have worked in.

Information Technology

Health care is an information-intensive and knowledge-intensive enterprise. Information technology can help healthcare providers acquire, manage, analyze, and disseminate both information and knowledge. Health care in the twenty-first century should be safe, effective, patient-centered, timely, efficient, and equitable (IOM, 2001). Comprehensive data on patients’ conditions, treatments, and outcomes are at the foundation of such care (Stead & Lin, 2009).

Computers offer the advantage of storing, organizing, retrieving, and communicating digital data with accuracy and speed. Patient care data can be entered once, stored in a database, and then quickly and accurately retrieved many times and in many combinations by healthcare providers and others. A **database** is a collection of data elements organized and stored together. Data processing is the structuring, organizing, and presenting of data for interpretation as information. For example, vital signs for one patient can be entered into the computer and communicated on a graph; many patients’ blood pressure measurements can be compared with the number of doses of anti-hypertension medication. Vital signs for male patients between the ages of 40 and 50 years can be correlated and used to show relationships with age, ethnicity, weight, presence of co-morbid conditions, and so on.

Humans process data continuously, but in an analog form. Computers process data in a digital form, process data faster and more accurately than humans,

Box 11-1 Development of Information Management Skills: Novice to Expert Practice

Novice nurses focus on learning what data to collect, the process of collecting and documenting the data, and how to use this information. They learn what clinical applications are available for use and how to use them. Computer and informatics skills focus on applying concrete concepts.

As nurses grow in expertise, they look for patterns in the data and information. They aggregate data across patient populations to look for similarities and differences in response to interventions. Expert nurses integrate theoretical knowledge with practical knowledge gained from experience.

Expert nurses know the value of personal professional reflection on knowledge and synthesize and evaluate information for discovery and decision making.

and provide a method of storage so that data can be retrieved as needed. The Theory Box provides key concepts of information processing, and Box 11-1 describes the development of information management skills from novice to expert.

Theory Box: Information Theory

Key Contributor

Key Ideas

Application to Practice

Locsin (2005): *Technological Competency as Caring in Nursing: A Model for Practice*

The realities of continuously advancing technologies in health care necessitate that contemporary nursing practice incorporates both the concepts of technology and caring.

Nurses practice in environments requiring technological expertise.

Technology has transformed the practice of nursing with the coexistence of caring and technology.

Competency with technology is demonstrated by registered nurses in skillful, intentional, deliberate, and authentic activities which engage technology in caring for patients and families.

Nurses can build a strong connection with patients and families through the competent use of technology.

Nurses at all stages of professional development need to acquire the skills to use technology competently.

When nurses are adept in the use of technology they engage it to care for patients. For example, the best online resources for patient/family education can be linked to clinical information systems and accessed when the ideal teaching moment is identified.

Nurses can influence patients and families to engage in their own care. Providing patients an electronic copy of their record or making patients aware of a patient portal, enrolling them with a portal account, and teaching them how to use it, are steps toward strengthening patient access to their health information and engagement in their own health care.

Locsin, R.C. (2005). *Technological competency as caring in nursing: A model for practice*. Indianapolis, IN: Sigma Theta Tau International.

Knowledge Technology

Knowledge technology consists of systems that generate or process knowledge and provide **clinical decision support** (CDS). Defined broadly, CDS is a clinical computer system, computer application, or process that helps health professionals make clinical decisions to enhance patient care. The clinical knowledge embedded in computer applications or work processes can range from simple facts and relationships to best practices for managing patients with specific disease states, new medical knowledge from clinical research, and other types of information. Among the most common forms of CDS are drug-dosing calculators—computer-based programs that calculate appropriate doses of medications after a clinician inputs key data (e.g., patient weight or the level of serum creatinine). These calculators are especially useful in managing the administration of medications with a narrow therapeutic index. Allergy alerts, dose range checking, drug-drug interaction, and duplicate order checking are other common applications of CDS.

**Clinical** (or diagnostic) **decision support systems** (CDSSs) are interactive computer programs designed to assist health professionals with decision-making tasks by mimicking the inductive or deductive reasoning of a human expert. The basic components of a CDSS include a knowledge base and an *inferencing mechanism* (usually a set of rules derived from the experts and evidence-based practice). The knowledge base contains the knowledge that an expert nurse would apply to data entered about a patient and information to solve a problem. The inference engine controls the application of the knowledge by providing the logic and rules for its use with data from a specific patient.

Box 11-2 illustrates the use of an expert system for determining the maximum dose of pain medication that can safely be given to a patient after an invasive procedure. The knowledge base contains eight items that are to be considered when giving the maximum dose. The inference engine controls the use of the knowledge base by applying logic that an expert nurse would use in making the decision to give the maximum dose. This decision frame states that if pain is severe (A) or a painful procedure is planned (B), and there is an order for pain medication (C) and the time since surgery is less than 48 hours (H) and the time since the last dose is greater than 3 hours (G), and there are no contraindications to the medication (D) or history of allergy (E) or contraindication to the maximum dose (F), then the “decision” would be

Box 11-2 Expert Decision Frame for “Give Maximum Dose of Pain Medication”

The Knowledge Base

A. Pain score

B. Invasive procedure scheduled

C. Opiate analgesic ordered

D. Contraindications to the medication

E. History of allergic reaction to opiate analgesics

F. Contraindication to maximum dose of opiate analgesic

G. Time since last dose of opiate analgesic administered

H. Time since surgical procedure

The Inference Engine

Give the maximum dose of pain medication if (A or B) and (C and H <48 hours and G >3 hours) and not (D or E or F)

**or:**

(C and H <48 hours and G >4 hours) and not (D or E or F)

to give the dose of pain medication. The rules are those that expert nurses would apply in making the decision to give pain medication.

Exercise 11-2

Mr. Jones’s heart rate is 54 beats per minute. Tony is about to give Mr. Jones his scheduled atenolol dose. When Tony scans Mr. Jones’s armband and the medication bar codes, the computer warns him that atenolol should not be given to a patient with a heart rate less than 60 beats per minute. What should Tony do?

One of the benefits of CDSSs is that they permit the novice nurse to advantage the decision-making expertise and judgment of an expert. Nursing leaders must be aware of the usefulness of decision support systems for nursing, as the development of CDS applicable to nursing practices is just beginning (IOM, 2011). Clinical experts are needed to develop both the knowledge in the database and the logic used to develop the rules for its application to a particular patient in a particular circumstance. Advanced critical thinking skills are needed to develop logic and rules. When these are in place, patient care quality can be standardized and improved.

A critical use of information has been in the area of the medication management process. These processes are high-risk and high-volume activities (Malashock, Smith-Shull, & Gould, 2004). New applications provide support for all aspects of the process, thereby improving safety and efficiency (Box 11-3).

Box 11-3 Information Technology: Trends in the Medication Management Process

Various information technology (IT) devices and software applications are designed to support the medication management process. Each has unique functionality and targets a specific phase of the medication process.

Computerized Provider Order Entry (CPOE)

• Decision support and clinical warnings (e.g., alerts the provider of allergies, pertinent laboratory data, drug-drug and drug-food interactions)

• Automatic dose calculation

• Link to up-to-date drug reference material

• Automatic order notification

• Standardized formulary-compliant order sets

• Legible, accurate, and complete medication orders

• Decreased variations in practice

• Less time clarifying orders

• Fewer verbal orders

• No manual transcription errors

Electronic Medication Administration Record (e-MAR)

• Integration with clinical documentation (in the electronic record)

• Link to up-to-date drug reference material

• Automatic reminders and alarms for approaching or missed medication administration times

• Prompts for associated tasks or additional documentation requirements

• Alert when cumulative dosing exceeds maximum

• Legible record

• Accessible to multiple users

• Improved accuracy of pharmacokinetic monitoring (administration times are reliable)

• Record matches the pharmacy profile

• Generated reports to track medication errors with visibility of near misses

• Perpetual interface with pharmacy inventory system

• Increase the accuracy of charge capture (at the time of administration vs. when drug is dispensed)

Bar Coding and Radio Frequency Identification (RFID) Scanning

• Medication documentation captured electronically at the time of administration (populates the e-MAR)

• Five rights verified

• Positive patient identification

• Clinician alerted to discrepancies (e.g., wrong drug, wrong dose, wrong time, wrong patient, expired drug)

• Automatic tracking of medication errors and provides visibility to near misses

“Smart” Infusion Pumps (Medication Infusion Delivery System)

• Reduced need for manual dose/rate calculation

• Institution defined standardized drug library (drugs, concentrations, dosing parameters)

• Software filter prevention of programming errors/programming within pre-established minimum and maximum limits before infusion can begin

• Device infusion parameter limits based on patient type or care area

• Interface with the patient’s pharmacy profile with capabilities to program the pump electronically

• User alerts to pump setting errors, wrong channel selection, and mechanical failures

• Electronic notification to pharmacy when fluids/medications need to be dispensed

• Interface with the patient’s e-MAR (accurate documentation of administration times and volumes infused)

• Memory functions for settings and alarms with a retrievable log

• Electronic recording of reprogramming and limit override activity

Automated Dispensing Unit/Cabinets

• Secured drug storage

• Controlled user access—biometric identification

• Interface with the pharmacy profile—access restricted until order reviewed

• Quick access once medication order reviewed by pharmacist

• Ability to monitor controlled substance waste and utilization patterns

• Perpetual interface with pharmacy inventory

Pharmacy Automation and Robotics

• Increased accuracy and speed of dispensing

From Bell, M.J. (2005). Nursing information of tomorrow. *Healthcare Informatics, 22*(2), 74-78; Larrabee, S., & Brown, M.M. (2003). Recognizing the institutional benefits of bar-code point-of-care technology. *Joint Commission Journal on Quality and Safety*, *29*(7), 345-353.

Information Systems

A patient information system can be manual or computerized—in fact, we have collected and recorded information about patients and patient care since the dawn of health care. Computer information systems manage large volumes of data, examine data patterns and trends, solve problems, and answer questions. In other words, computers can help translate data into information. Ideally, data are recorded at the point in the care process where they are gathered and are available to healthcare providers when and where they are needed. This is accomplished, in part, by networking computers both within and among organizations to form larger systems. These networked systems might link inpatient care units and other departments, hospitals, clinics, hospice centers, home health agencies, and/or physician practices. Data from all patient encounters with the healthcare system are stored in a central data repository, where they are accessible to authorized users located anywhere in the world. These provide the potential for automated patient records, which contain health data from birth to death.

Adopting the technology necessary to computerize patient care information systems is complex and must be accomplished in stages. The Healthcare Information and Management Systems Society (HIMSS) has described seven stages of adoption—the seventh of which marks achievement of a fully electronic healthcare record. The seven stages of adoption are listed and described in Table 11-1. About 5.2% of U.S. hospitals have achieved stage 6, 1.2% have achieved stage 7, and less than 10% are at stage 0 (HIMSS Analytics, 2012).

Nurses care for patients in acute care, ambulatory, and community settings, as well as in patients’ homes. In all settings, nurses focus not only on managing acute illnesses but also on health promotion, maintenance, and education; care coordination and continuity; and monitoring chronic conditions. Ideally, information systems support the work of nurses in all settings.

Table 11-1 Electronic Medical Record Adoption Model\*

US EMR Adoption Model$M

Stage

Cumulative Capabilities

2010 Q4

2011 Q4

Stage 7

Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED, ambulatory, OP

1.0%

1.2%

Stage 6

Physician documentation (structured templates), fill CDSS (variance & compliance), full R-PACS

3.2%

5.2%

Stage 5

Closed loop medication administration

4.5%

8.4%

Stage 4

CPOE, Clinical Decision Support (clinical protocols)

10.5%

13.2%

Stage 3

Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology

49.0%

44.9%

Stage 2

CDR, Controlled Medical Vocabulary, CDS, may have Document Imaging; HIE capable

14.6%

12.4%

Stage 1

Ancillaries – Lab, Rad, Pharmacy – All Installed

7.1%

5.7%

Stage 0

All Three Ancillaries Not Installed

10.1%

9.0%

Data from HIMSS Analytics® Database ©2011

N=5.299

N=5.337

⁎ From HIMSS Analytics, Healthcare Information and Management Systems Society. 2012 HIMSS Analytics Report. (2012). *Quality and safety linked to advanced information technology enabled processes*. Retrieved February 12, 2012 from http://www.himssanalytics.org/emram/emram.aspx.

Communication networks are used to transmit data entered at one computer and received by others in the network. These networks can reduce the clerical functions of nursing. They can provide patient demographic and census data, results from tests, and lists of medications. Nursing policies and procedures can be linked to the network and accessed, when needed, at the point of care. Links can be provided between the patient’s home, hospital, and/or physician office with computers, handheld technologies, and point-of-care devices. Day-to-day events can be recorded and downloaded into the patient record remotely in community nursing settings or at the point of care in the hospital or clinic.

Exercise 11-3

Select a healthcare setting with which you are familiar. What information systems are used? Make a list of the names of these systems and the information they provide. How do they help you in caring for patients or in making management decisions? Think about the communication of data and information among departments. Do the systems communicate with each other? If you do not have computerized systems, think about how data and information are communicated. How might a computer system help you be more efficient?

As an example, assume that an abdominal magnetic resonance imaging (MRI) with contrast has been ordered. In a paper-based system, handwritten requisitions are sent to nutrition services, pharmacy, and the radiology department. With a computerized system, the MRI is ordered and the requests for dietary changes, bowel preparation medications, and the diagnostic study itself are automatically sent to the appropriate departments. Radiology would compare its schedule openings with the patient’s schedule and automatically place the date and time for the MRI on the patient’s automated plan of care. The images and results of the diagnostic procedure are available online.

Nurses caring for patients in home health care and hospice must complete documentation necessary to meet government and insurance requirements. Computers assist with direct entry of all required data in the correct format. Portable computers are used to download files of the patients to be seen during the day from a main database. During each visit, the computer prompts the nurse for vital signs, assessments, diagnosis, interventions, long-term and short-term goals, and medications based on previous entries in the medical record. Nurses enter any new data, modifications, or nursing information directly. Entries can be transmitted by telephone line to the main computer at the office or downloaded from the device at the end of the day. This action automatically updates the patient record and any verbal order entry records, home visit reports, federally mandated treatment plans, productivity and quality improvement reports, and other documents for review and signature. Portable and wireless computers have made recording patient care information more efficient and have improved personnel productivity and compliance with necessary documentation.

Placing computers or handheld devices “patient-side” permits nurses to enter data once, at the point of care. Documentation of patient assessments and care provided patient-side saves time, gives others more timely access to the data, and decreases the likelihood of forgetting to document vital information. Point-of-care devices and systems that fit with nurses’ workflow, personalize patient assessments, and simplify care planning are available. Patient care areas with point-of-care computers have improved the quality of patient care by decreasing errors of omission, providing greater accuracy and completeness of documentation, reducing medication errors, providing more timely responses to patient needs, and improving

A handheld computer permits point-of-care documentation.



discharge planning and teaching. These systems can eliminate redundant charting and facilitate patient hand-offs from shift to shift or between care areas (Laws & Amato, 2010).

Exercise 11-4

Think about the data you gather as you care for a patient through the day. How do you communicate information and knowledge about your patient to others? Does the information system support the way you need this information organized, stored, retrieved, and presented to other healthcare providers? For example, if a patient’s pain medication order is about to expire and you want to assess the patient’s use and response to the pain medication during the past 24 hours, can the information system generate a graph that compares the time, dose, and pain score for this period? If your assessment is that the medication order needs to be renewed, how do you communicate that message to the prescriber?

Meaningful Use

The potential of electronic health records (EHRs) to benefit caregivers, patients, and their families depends on how they are used. **Meaningful use** (MU) is the set of standards defined by the Medicare and Medicaid Electronic Health Records (EHR) Incentive Programs that governs the use of EHRs and allows eligible providers and hospitals to earn incentive payments by meeting specific criteria. The goal of MU is to promote the implementation and effective use of EHRs to improve health care in the United States (Smith & Burnes Bolton, 2013). The benefits of the meaningful use of EHRs include:

• *Complete and accurate information*. With EHRs, care providers have the information they need to provide the best possible care.

• *Better access to information*. EHRs facilitate greater access to the information needed to diagnose and treat health problems earlier and improve health outcomes for patients. EHRs allow information to be shared among offices, hospitals, and across health systems, which facilitates care coordination.

• *Patient empowerment*. EHRs can empower patients and families to take a more active role in their health. They can receive electronic copies of their healthcare records and share their health information securely over the Internet with their families and care providers.

In order to achieve MU, eligible providers and hospitals must adopt an EHR that has the technical capabilities to ensure the systems are capable of performing defined required functions. Thereafter, providers and hospitals must use the technology to achieve specific objectives.

The MU objectives and measures evolve over 5 years: Stage 1 is capturing and sharing data via EHRs. Stage 2 is advancing clinical processes with EHRs. Stage 3 is requiring that providers and hospitals use EHRs to demonstrate improved patient outcomes (Table 11-2).

Information Systems Quality and Accreditation

Quality management and measuring patient care efficiency, effectiveness, and outcomes are necessary for

Table 11-2 Stages of Meaningful Use

Stage 1 Criteria Focus On:

Stage 2 Criteria Focus On:

Stage 3 Criteria Focus On:

Electronically capturing health information in a standardized format

More rigorous health information exchange (HIE)

Improving quality, safety, and efficiency, leading to improved health outcomes

Using that information to track key clinical conditions

Increased requirements for e-prescribing and incorporating lab results

Decision support for national high-priority conditions

Communicating that information for care coordination processes

Electronic transmission of patient care summaries across multiple settings

Patient access to self-management tools

Initiating the reporting of clinical quality measures and public health information

More patient-controlled data

Access to comprehensive patient data through patient-centered HIE

Using information to engage patients and their families in their care

Improving population health

Source: www.healthit.gov/policy-researchers-implementers/meaningful-use. Nursing leaders can learn more about MU at http://healthit.gov.

accreditation and licensing of healthcare organizations. This is demonstrated by documentation of patient care processes and outcomes. The plan of care outlines what patient care needs to occur, orders are entered to prescribe needed care, and documentation confirms that the care was provided. Computers can capture and aggregate data to demonstrate both the processes of care and the patient outcomes achieved.

The Joint Commission (TJC), an independent, not-for-profit organization, evaluates and provides accreditation and certification to more than 15,000 healthcare organizations and programs in the United States. Accreditation and certification by TJC are recognized nationwide as symbols of an organization’s commitment to meeting performance standards focused on improving the quality and safety of patient care.

The *Comprehensive Accreditation Manual for Hospitals* and the manuals for other healthcare programs include a chapter of standards for information management. Planning for information management is the initial focus of the chapter, since a well-planned system meets the internal and external information needs of an organization with efficiency and accuracy. The goals of effective information management are to obtain, manage, and use information to improve patient care processes and patient outcomes, as well as to improve other organizational processes. Planning is also necessary to provide care continuity should an organization’s information systems be disrupted or fail. Planning also is necessary to ensure privacy, security, confidentiality, and integrity of data and information.

In the 2013 TJC accreditation manual chapter “The Record of Care, Treatment and Services,” standards and recommendations for the components of a complete medical record are provided. It details documentation requirements that include accuracy, authentication, and thorough, timely documentation. Other standards address the requirements for auditing and retaining records (TJC, 2013b).

All nurses, including nurse leaders, share responsibility to ensure that cost-effective, high-quality patient care is provided. Nursing administrative databases, containing both clinical and management data, support decision making for these purposes. Administrative databases assist in the development of the organization’s information infrastructure, which ultimately allows for links between management decisions (e.g., staffing or nurse/patient ratios), costs, and clinical outcomes.

Selection of a clinical information system and software partner may be one of the most important decisions of a chief nursing officer and the nursing leadership team. Nurse leaders and direct care nurses must be members of the selection team, participate actively, and have a voice in the selection decision. Remember, nurses are knowledge workers who require data, information, and knowledge to deliver effective patient care. The information system must make sense to the people who use it and fit effectively with the processes for providing patient care. Box 11-4 identifies

Box 11-4 Elements of the Ideal Hospital Information System

• Data are standardized and use structured terminology.

• The system is reliable—minimal scheduled or unscheduled downtime.

• Applications are integrated across the system.

• Data are collected at the point of care.

• The database is complete, accurate, and easy to query.

• The infrastructure is interconnected and supports accessibility.

• Data are gathered by instrumentation whenever possible so that only minimal data entry is necessary.

• The system has a rapid response time.

• The system is intuitive and reflective of patient care delivery models.

• The location facilitates functionality, security, and support.

• Screen displays can be configured by user preference.

• The system supports outcomes and an evidence-based approach to care delivery.

key elements of an ideal clinical information system that can guide the decision making necessary for selecting or developing health information software. Before making a selection, visit organizations already using the software to obtain practical and strategic information. Discussions at site visits include both the utility and performance of the software and the customer service and responsiveness of the vendor.

Information Systems Hardware

Placing the power of computers for both entering and retrieving data at the point of patient care is a major thrust in the move toward increased adoption of clinical information systems. Many hospitals and clinics are using a number of computing devices in the clinical setting—desktop, laptop, or, increasingly, tablet computers; and smart phones—as we learn about both the possibilities and limitations of different hardware solutions. Theoretically, nurses may work best with robust mobile technology. Installing computers on mobile carts, also known as *computers on wheels* or *COWs,* may increase work efficiency and save time. However, if the cart is cumbersome to move around or if concern about infection risk is associated with moving the cart from one room to another, some organizations favor keeping one cart stationed in each patient care room or installing hardwired bedside computers.

Wireless Communication

Wireless (WL) communication is an extension of an existing wired network environment and uses radio-based systems to transmit data signals through the air without any physical connections. Telemetry is a clinical use of WL communication. Nurses can communicate with other healthcare team members, departments, and offices and with patients through the use of pagers, smart phones, and wireless computers. Nurses can send and receive e-mail, clinical data, and other text messages. The Internet can be accessed on these devices.

WL systems are used by emergency medical personnel to request authorization for the treatments or drugs needed in emergency situations. Laboratories use WL technology to transmit laboratory results to physicians; patients awaiting organ transplants are provided with WL pagers so that they can be notified if a donor is found; and parents of critically ill children carry WL pagers when they are away from a phone. Visiting nurses using a home monitoring system employ WL technology to enter vital signs and other patient-related information. Inpatient nurses can send messages to the admissions department when a patient is being transferred to another unit without having to wait for someone to answer the telephone. Increasingly, whole hospitals use WL technology to deploy their information systems to the point of patient care.

New hardware for patient information systems has both advantages and disadvantages. Portable devices, such as smart phones and tablet computers, are less expensive than placing a stationary computer in each patient room. In addition, each caregiver on a shift can be equipped with a device. Portable, handheld devices allow access to information at the point of care, both for retrieval of information and entry of patient data. Disadvantages stem from their size and portability. They have a small display screen, limiting the amount of data that can be viewed on the screen and the size of the font. Portable devices can also be put down and forgotten, dropped and broken, and targeted for theft. Small devices require a convenient and adequate place to store the devices when they are not in use and to charge their batteries, when needed. Finally, WL technology may not operate with the speed necessary to advantage busy healthcare workers in fast-paced environments.

Management of the hardware designed to advantage clinical information system software is important. Nursing leaders must make knowledgeable decisions about the type of hardware to use, the education needed to use it effectively, and the proper care and maintenance of the equipment. Important questions to ask include the following: What data and information do we need to gather? When and where should it be gathered? How difficult is the equipment to use? Has the hardware been tested sufficiently to ensure purchase of a dependable product?

Communication Technology

**Communication technology** is an extension of WL technology that enables hands-free communication among mobile hospital workers. Hospital staff members wear a pendant-like badge around their neck and, by simply pressing a button on the badge, can be connected to the person with whom they wish to speak by stating the name or function of the person.

Voice technology may also enhance the use of computer systems in the future. **Speech recognition (SR)** is also known as *computer speech recognition*. The term *voice recognition* may also be used to refer to speech recognition but is less accurate. SR converts spoken words to machine-readable input. SR applications in everyday life include voice dialing (e.g., “Call home”), call routing (e.g., “I would like to make a collect call”), and simple data entry (e.g., stating a credit card or account number). In health care, preparation of structured documents, such as a radiology report, is possible. In all these examples, the computer gathers, processes, interprets, and executes audible signals by comparing the spoken words with a template in the system. If the patterns match, recognition occurs and a command is executed by the computer. This allows untrained personnel or those whose hands are busy to enter data in an SR environment without touching the computer. Voice technology will also allow quadriplegic and other physically challenged individuals to function more efficiently when using the computer. SR systems recognize a large number of words but are still immature. The speaker must use staccato-like speech, pausing between each clearly spoken word; and these systems must be programmed for each user so that the system recognizes the user’s voice patterns.

Automating the healthcare delivery process is not an easy task. Patient care processes are often not standardized across settings, and most software vendors cannot customize software for each organization. Some current versions of the electronic patient record have merely automated the existing schema of the chart rather than considering how computers could permit data to be viewed or used differently from manual methods. The complexity of decision making about health information systems software and hardware has given rise to the science of informatics.

Informatics

**Informatics** is “a science that combines a domain science, computer science, information science, and cognitive science” (Hunter, 2001, p. 180). The term *nursing informatics* was probably first used and defined by Scholes and Barber in 1980 in their address to the International Medical Informatics Association (IMIA) at the conference that year in Tokyo. They defined nursing informatics as “the application of computer technology to all fields of nursing—nursing services, nurse education, and nursing research” (p. 73).

Nursing informatics is now a thriving subspecialty of nursing that combines nursing knowledge and skills with computer expertise. Like any knowledge-intensive profession, nursing is greatly affected by the explosive growth of both scientific advances and technology. Nurse informatics specialists manage and communicate nursing data and information to improve decision making by consumers, patients, nurses, and other healthcare providers. Nurse informatics specialists formed the American Nursing Informatics Association (ANIA) in the early 1990s to provide networking, education, and information resources that enrich and strengthen the roles of nurses in the field of informatics, including the domains of clinical information, education, and administration decision support. In addition, nursing informatics is represented in the American Medical Informatics Association (AMIA) and the IMIA by working groups that promote the advancement of nursing informatics within the larger interdisciplinary context of health informatics.

The Nursing Informatics Working Group of AMIA defined their practice specialty 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” (*www.AMIA.org/programs/working-groups/nursing-informatics*).

Many undergraduate and graduate nursing education programs recognize that it is essential to prepare nurses to practice in a technology-rich environment (National League of Nursing [NLN], 2008; Warren & Connors, 2007). Noting the federal initiatives pushing the adoption of electronic health records throughout all healthcare institutions by the year 2014, the NLN stressed that it is imperative that graduates of today’s nursing programs know how to use and advantage “informatics tools to ensure safe and quality care” (NLN, 2008, p. 1). Certification as a nurse informatics specialist by the American Nurses Credentialing Center (ANCC) requires specific coursework and specific experience and/or continuing education.

Informatics is interdisciplinary and in its truest form, it focuses on the care of patients rather than on a specific discipline (Hannah & Ball, 2011). Although specific bodies of knowledge exist for each healthcare profession (e.g., nursing, dentistry, dietetics, pharmacy, medicine), they interface at the patient. Working with integrated clinical information systems demands interdisciplinary collaboration at a high level.

Patient Safety

The patient care environment is complex and prone to errors. Nurses are the healthcare workers who prevent accidents in patient care and create safety daily (IOM, 2004). In addition to physical challenges, resource challenges, and interruptions characteristic of nursing work, nurses are challenged by inconsistencies and breakdowns in care communication. Communication and information difficulties are among the most common nursing workplace challenges and are frustrating and potentially dangerous for patients.

Information technology is identified as an essential tool for advancing patient safety (Malloch, 2007). Nurses, other health professionals, and patients and families rely increasingly on information technology to communicate, manage information, mitigate error potential, and make informed decisions (Bakken et al., 2004; Marin, 2004). Health information technology has the potential to improve—or obstruct—work performance, communication, and documentation (Ash, Berg, & Coiere, 2004). Because nurses play a central role in patient care, the extent to which information technology supports or detracts from nurses’ work performance can be expected to affect patient outcomes (Kossman & Scheidenhelm, 2008).

Nurses identified that the highest percentage of their top 10 challenges are related to systems and technology put in place to accomplish patient care (Krichbaum et al., 2007). Nurses spend up to 40% of their workday meeting ever-increasing demands from the systems in which they work to provide patient care (Ebright, Patterson, Chalko, & Render, 2003). Nurses rank new, excessive, or changing forms and documentation systems number 2 among the variables contributing most to complexity compression. Only inadequate staffing ranks higher (Krichbaum et al., 2007).

Documentation to meet organizational, accreditation, insurance, state, and federal requirements, as well as provide information needed by other healthcare providers, imposes a heavy demand on nurses’ time. Documentation requirements lessen nursing time for direct contact with patients and families. Westbrook, Duffield, Li, and Creswick (2011) reported that nurses spent approximately 37% of their time with patients. Reduced nursing availability affects patient safety and care quality. Nurses in acute care settings spend, on average, one quarter to one half of their time documenting patient care (Ammenwerth, Mansmann, Iller, & Eichstadter, 2003; Frankel, Cowie, & Daley, 2003; Korst, Eusebio-Angeja, Chamorro, Aydin, & Gregory, 2003; Kossman & Scheidenhelm, 2008). Finishing documentation is one reason nurses do not complete work on time—it is a form of mandatory overtime (Trossman, 2001).

Impact of Clinical Information Systems

Clinical information systems that provide access to patient information and provide clinical decision support can reduce errors and inefficiencies (Ball, Weaver, & Abbot, 2003). Patient information in an electronic clinical information system is organized and legible. Nurses see all of the medications prescribed for a patient in one location; doses are written clearly, and drug names are spelled correctly. The patient problem list shows acute and chronic health conditions and complete allergy information. Abnormal findings are highlighted and can be graphed and compared with interventions. Alerts signal nurses that critical information has been entered in the electronic record. For example, critical test results signal the need for provider notification and intervention. An alert that a patient is at risk for falling signals the need for additional monitoring and interventions to ensure safety. Nursing reminders to perform pressure area care reduce the incidence of this important hospital acquired condition.

When standards for care are not being followed, clinical information systems can generate alerts, reminders, or suggestions. Rules remind care providers to perform required care. When documentation is not recorded for medication administration, IV tubing change, or wound care, for example, the system generates a reminder based on rules that have been agreed to by providers. Evidence-based practices are integrated in the process of care as providers are guided to select the most appropriate course of action.

Errors are prevented by eliminating problems stemming from illegible handwriting. Computerized order entry also eliminates the nursing time required for clarification of illegible and incomplete orders. Transcription is no longer required, orders are sent directly to the performing department, and patient care needs are communicated more clearly and quickly to all clinicians. Medication dosing, drug allergy, and drug-drug interaction checking all have significant impact on patient safety (Mekhjian et al., 2002).

Impact on Communication

Integrated information systems allow all members of the interdisciplinary patient care team to see pertinent patient information and plan care based on what is currently happening and what should occur in the future. Everyone knows who is responsible for the patient and who needs to communicate about the patient’s care. Clinical information systems provide multiple users with simultaneous, real-time access to patient records. Patient care hand-offs are safer when information is not unavailable or lost in the process. Patient care processes are facilitated, and treatment delays are decreased. The patient’s care experience is also improved by decreasing redundant data collection by multiple members of the care team.

Impact on Patient Care Documentation

Nurses spend much time documenting patient care activities. Clinical documentation in an electronic information system improves access to patient information and increases documentation efficiency and organization (Kossman & Scheidenhelm, 2008). In an intensive care setting, automatic downloads of patient vital signs, ventilator settings, and IV intake provide efficiency and are timesaving for nurses (Frankel, Cowie, & Daley, 2003). Redundant documentation is eliminated with an integrated clinical information system, and completeness of nursing documentation has increased with some systems (Larrabee et al., 2001).

Impact on Medication Administration Processes

The *Quantros MEDMARX* database includes annual records of medication errors. In 2006, approximately 25% of errors involved some aspect of computer

Bar code medication administration “closes the loop” on medication safety by providing a double-check of the five rights of medication administration at the point nurses actually give patients their ordered medications.



technology as at least one cause of the error. Most errors related to technology involved mislabeled bar codes on medications, mistakes at order entry because of confusing computer screens, or other problems with information management (TJC, 2008). Errors also were related to dispensing devices and human factors, such as failure to scan bar codes or overrides of bar-code warnings.

**Computerized provider order entry (CPOE)** can be an effective mechanism for improving patient safety. Unintended consequences however can occur, and new kinds of errors can be detected (Ash et al., 2007). Safeguards built into clinical information systems can avert an error, but awareness of the potential for new issues is vital.

Automated medication administration systems that use **bar-code technology** can ensure that the right patient gets the right medication, in the correct dose, by the appropriate route, and at the specified time. However, this new information technology must not impede nurses’ care of patients. Faced with urgent or emergent situations with patients, technical difficulties, or poor work re-design, unorthodox and potentially unsafe work-arounds are sometimes invented when the medication administration system is not usable and obstructs patient care (Koppel, Wetterneck, Telles, & Karsh, 2008).

Closed-loop electronic prescribing, dispensing, and bar-code patient identification systems reduce prescribing errors and medication adverse events and increase confirmation of patient identity before administration. However, time spent on medication-related tasks increases for physicians, pharmacists, and nurses (Franklin, O’Grady, Donyai, Jacklin, & Barber, 2007).

Safely Implementing Health Information Technology

Despite the promise of positive impact from clinical information systems, success is not a guarantee. Remaining alert to its limitations and risks is crucial, because new technology and increasing automation make work less transparent and create opportunities for new types of errors (Reason, 2002). According to McBride (2005):

Information technology is not a panacea, and will not fulfill its promise unless it is harnessed in support of foundational values. That is why every nurse cannot afford to be unconnected to this transformation, but must take an active role in ensuring that IT is used in service to our profession’s values. After all, nurses are knowledge workers. (p. 188)

The Joint Commission warns that as health information technology is adopted, users must be mindful of the safety risks and preventable adverse events that implementation can create (TJC, 2008). The report notes that any form of technology can adversely affect patient care safety and quality if it is designed or implemented improperly. TJC suggests 13 actions, which are presented in Table 11-3.

A clinical information system’s success or failure is related to the system’s “fit” with the organizational culture, the information needs of its users, and users’ work processes and practices (Kaplan, 2001; Kaplan & Harris-Salamone, 2009). Duke University Medical Center informatics experts wrote that they had learned in 1993 that “ongoing planning, adjusting, fitting the technology to the work, and adapting policy formation were more important than the technology itself” (Stead et al., 1993, p. 225). The same is true today!

Relying too heavily on health information technology for communication can reduce teamwork and may negatively affect patient safety and care quality (Ash et al., 2004). Although improved access and better-organized information can eliminate nurses’ locating information for other nurses and physicians,

Table 11-3 The Joint Commission Recommendations for Safely Implementing Health Information Technology

Suggested Action

  1

Examine work processes and procedures for risks and inefficiencies. Resolve problems identified before technology implementation. Involve representatives of all disciplines—clinical, clerical, and technical—in the examination and resolution of issues.

  2

Involve clinicians and staff who will use or be affected by the technology, along with information technology (IT) staff with strong clinical backgrounds, in the planning, selection, design, reassessment, and ongoing quality improvement of technology. Involve pharmacists in planning and implementing any technology that involves medication.

  3

Assess your organization’s technology needs. Require IT staff to interact with users outside their own facility to learn about real-world capabilities of potential systems from various vendors; conduct field trips; look at integrated systems to minimize the need for interfaces.

  4

Continuously monitor for problems during the introduction of new technology and address issues as quickly as possible to avoid workarounds and errors. Consider an emergent issues desk staffed with project experts and champions to help rapidly resolve problems. Use interdisciplinary problem solving to improve system quality and provide vendor feedback.

  5

Establish training programs for all clinical and operations staff, designed appropriately for each group and focused on how the technology will benefit staff and patients. Do not allow long delays between training and implementation. Provide frequent refresher courses or updates.

  6

Develop and communicate policies delineating staff authorized and responsible for technology implementation, use, oversight, and safety review.

  7

Ensure that all order sets and guidelines are developed, tested, and approved by the Pharmacy and Therapeutics Committee (or equivalent) before implementation.

  8

Develop a graduated system of safety alerts in the new technology to help clinicians determine urgency and relevancy. Review skipped or rejected alerts. Decide which alerts need to be hard stops in the technology and provide supporting documentation.

  9

Develop systems to mitigate potential computerized provider order entry (CPOE) drug errors or adverse events by requiring department and pharmacy review and sign off. Use the Pharmacy and Therapeutics Committee (or equivalent) for oversight and approval of electronic order sets and clinical decision support (CDS) alerts. Ensure proper nomenclature and printed label design, eliminate dangerous abbreviations and dose designations, and ensure electronic medication administration record (e-MAR) acceptance by nurses.

10

Provide environments that protect staff doing data entry from undue distractions when using the technology.

11

Maximize the potential of the technology to maximize safety. Continually reassess and enhance safety effectiveness and error detection. Use error-tracking tools, and evaluate events and near-miss events.

12

Monitor and report errors and near-miss events. Pursue potential system errors or use problems with root cause analysis or other forms of failure-mode analysis. Consider reporting significant issues to external reporting systems.

13

Re-evaluate the applicability of security and confidentiality protocols. Reassess Health Insurance Portability and Accountability Act (HIPAA) compliance periodically to ensure that the addition of technology and the growing responsibilities of IT staff have not introduced new security or compliance risks.

Copyright © The Joint Commission, 2014. Reprinted with permission.

information technology will never eliminate the need for personal communication and teamwork.

Successful development and implementation of nursing information technology depend on nurses working in partnership with organizational leadership, information systems vendors, and systems analysts to create tools that truly benefit nurses. When nurses have the systems and tools needed to provide patient care effectively and efficiently, safety and care quality will follow. Direct-care nurses must work with informatics nurses and information system developers and programmers in system development, implementation, and ongoing improvement. Nurses are key partners in every phase of the clinical information life cycle (Benham-Hutchins, 2009). By combining computer and information science with nursing science, the goals of supporting nursing practice and the delivery of high-quality nursing care can be achieved (Delaney, 2007). The Literature Perspective on p. 203 identifies some recommendations related to health information technology (HIT) successes and failures.

 Literature Perspective: Technology and Nursing Resource Planning

**Resource:** Harper, E.M. (2012). Staffing based on evidence: Can health information technology make it possible? *Nursing Economics, 30,* 262-267.

The potential to use health information technology as a tool to manage effective use of nursing resources is a fairly new topic that has only recently been explored by leaders in nursing informatics (Douglas, 2011; Douglas, 2010; Hyun, Bakken, Douglas, & Stone, 2008). It is a significant topic because a clear and compelling case has been demonstrated for the association of nurses, nursing care, and clinical outcomes for patients and financial outcomes for organizations (Aiken, Clark, Sochalski, & Silber, 2002; American Nurses Association, 2010; Douglas, 2010; Eck-Birmingham, 2010). Nonetheless, leaders must balance nursing staffing and care quality against financial constraints in an era of cost containment.

There is little agreement of the best approach to achieve nurse/patient ratios that support safe, high-quality nursing care for all patients. A strict ratio may ignore individual patient care needs; whereas attempts to capture details about care needs or derive a formula that precisely predicts care needs and forecasts required staff requirements are very difficult and have not been broadly agreed upon.

Harper (2012) reported a pilot study that used a clinical information system (CIS) to identify factors that lead to a model that predicts nursing care needs. In the pilot study, a Clinical Demand Index was developed by identifying how nurses spend their time, using the CIS for data mining, and identifying variables most closely related to how nurses spend their time. The pilot demonstrated that clinical data from the electronic health record can be extracted in real time and used to calculate the intensity of nursing care required by patients in a given clinical setting.

Implications for Practice

Can you think of patient care activities that should be included in a measurement of nursing care intensity? Administering medications, monitoring patients following a procedure, and admitting a new patient for an inpatient stay are a few examples. Which of these have you documented electronically during your nursing education? Are there other nursing care activities that you regularly and routinely document? Were you aware of the potential to mine data from the clinical information system? What protections for patient information security need to be in place to ensure confidentiality and personal health information are not jeopardized by an initiative such as this?

Imagine that a patient you are caring for complains of light-headedness and nausea. When documenting vital signs, you note that the blood pressure measurement is lower than it was the day before. Graphing the values across several days illustrates a steady decline in the readings. Reviewing the medication list, you note he is receiving hydralazine (Apresoline). Processing the data that you have collected, you implement “falls precautions,” send a communication order to monitor his blood pressure and other symptoms frequently, and notify the physician if the situation has not changed.

Exercise 11-5

Think about the data that you gather and document every day: vital signs, intake and output, laboratory and test results, and the patient’s responses to care. What data did you automatically combine or reorganize to help you make a decision regarding patient care? How did you use this information to improve your patient’s outcome? How and with whom did you communicate the data and information? How did technology combine or organize data?

Future Trends and Professional Issues

Biomedical Technology

Numerous devices continue to be developed. As an example, twenty-first century IV pumps offer safety features, accuracy, advanced pressure monitoring, ease of use, and versatility.

Information Technology

Health care in the United States is expensive and of variable quality. Recognizing that informatics can play an important role in controlling costs and improving quality, the federal government’s economic stimulus

Twenty-first century IV pumps offer safety features, accuracy, advanced pressure monitoring, ease of use, and versatility.



plan in 2009 earmarked $20 billion for health information technology. However, the money must be spent wisely, not quickly. One consideration suggested was to use the money to move the health information technology industry toward strong, mandated data standards. Data standards are at the foundation of integrated, interoperable information systems that will permit an emergency department or operating room to transfer data to inpatient hospital units and permit hospitals to send data to a patient’s primary care record in the provider’s office.

Electronic Patient Care Records

Multiple terms have been used to define electronic patient care records, with overlapping definitions. Both **electronic health record (EHR)** and **electronic medical record (EMR)** have gained widespread use, with some health informatics users assigning the term *EHR* to a global concept and *EMR* to a discrete localized record. An EHR refers to an individual patient’s medical record in digital format. The EHR is a longitudinal electronic record of patient health information generated across encounters in any care delivery setting. EHR systems coordinate the storage and retrieval of individual records with the aid of computers. The EHR is most often accessed on a computer, often over a network, and may include EMRs from many locations and/or sources. Among the many forms of data often included are patient demographics, health history, progress and procedure notes, health problems, medication and allergy lists (including immunization status), laboratory test results, radiology images and reports, billing records, and advance directives.

Credit card–like devices called **smart cards** store a limited number of pages of data on a computer chip. The implementation of computer-based health information systems will lead to computer networks that will store health records across local, state, national, and international boundaries. The smart card serves as a bridge between the clinician terminal and the central repository, making patient information available to the caregiver quickly and cheaply at the point of service because the patients bring it with them. This will help coordinate care; improve quality-of-care decisions; and reduce risk, waste, and duplication of effort. Patients are mobile and consult many practitioners, thereby causing their records to be fragmented. With the electronic smart card, patients, providers,

Box 11-5 Smart Cards

1. Patient demographics/photo identification

2. ICE—in case of emergency—contact and other key information

3. Patient medical history: for example, allergies, medications, immunizations, laboratory results

4. Past care encounter summaries, including surgical procedures

5. Patient record locations and electronic address information

6. Ability to upload or download patient information

and notes can be brought together in any combination at any place. Box 11-5 provides examples of the types of data that are recorded on smart cards.

Data Privacy and Security

Data protection, systems’ security, and patient privacy are concerns with electronic health records. However, patients’ rights to privacy of their data must be maintained whether recorded in a manual or automated system. With computerized data, any person with the proper permission may access the information anywhere in the world and multiple people can do so simultaneously. Data can also be inadvertently sent to the wrong individual or site. Information security and privacy are important concerns as development of electronic health information systems accelerates at the beginning of the twenty-first century.

A firewall protects the information in the central data repository from access by unauthorized users. It is a network security measure that keeps electronic intruders from accessing an organization’s data on its private network while allowing members of the organization to reach the Internet. Organizational policies on the use, security, and accuracy of data must be developed and monitored for compliance.

Communication Technology

Telecommunications

Telecommunications and systems technology facilitate clinical oversight of health care via telephone or cable lines, remote monitoring, information links, and the Internet. **Telehealth** is the use of modern telecommunications and information technologies for the provision of health care to individuals at a distance and the transmission of information to provide that care. This is accomplished using two-way interactive videoconferencing and high-speed telephone lines, fiberoptic cable, and satellite transmissions. Patients sitting in front of the teleconferencing camera can be diagnosed, treated, monitored, and educated by nurses and physicians. EKGs and radiographs can be viewed and transmitted. Sophisticated electronic stethoscopes and dermascopes allow nurses and physicians to hear heart, lung, and bowel sounds and to look closely at wounds, eyes, ears, and skin. Ready access to expert advice and patient information is available no matter where the patient or information is located. Patients in rural areas and prisons especially benefit from this technology.

Telecommunication also supports distance learning, which has been possible for some years, with enhanced opportunities to engage learners in online classrooms. With online or “virtual” classrooms, learners from anywhere in the world with computer access can log into a university’s or other group’s online learning system via the Internet.

Informatics

In 2011, the Healthcare Information and Management Systems Society (HIMSS) identified that just over 90% of American hospitals had implemented some component of an EMR. The American Nurses Association recognized nursing informatics as a specialty nursing practice in 2001. Although more than 8000 nurses are practicing in informatics, many more are needed to achieve widespread development and adoption of effective health information systems (Sensmeier, 2008).

Many opportunities exist to improve the safety, efficiency, and effectiveness of nursing care. The goal of informatics nurses and nursing leaders is to use information technology to ensure that critical information is available to caregivers at the point of care to make health care safer and more effective while improving efficiency. This requires interconnected and integrated healthcare technology across hospitals, healthcare systems, and geographic regions. Standards for data systems that operate efficiently with one another (termed “interoperability”) and attention to data security and patient privacy are necessary.

Nurses are working as leaders in several national initiatives to lay the groundwork and guide progress toward the goal of a nationwide health information network. Every nurse can embrace technology to improve nursing practice. Some strategies to accomplish this include (1) involving nurses in every decision about health IT that affects their workflow, (2) investing in training nurses to effectively use technology in their practice, and (3) leveraging opportunities to use IT to enable quality improvement (Sensmeier, 2008).

Knowledge Technology

Technology has the potential to shorten the many years that currently exist between the development of new knowledge for patient care and the application of that knowledge in real-time practice with patients. Increasingly, patient conditions that are directly influenced by nursing care are part of the Centers for Medicare & Medicaid Services (CMS) pay for performance and The Joint Commission “never events.” Having the best knowledge available regarding clinical phenomena is increasingly important. The focus of nursing care includes medication management, activity intolerance, immobility, risk for falls and actual falls, risk for skin impairment and pressure ulcer, anxiety, dementia, sleep, prevention of infection, nutrition, incontinence, dehydration, smoking cessation, pain management, patient and family education, and self-care.

Norma Lang, a nursing informatics leader, has described the challenges of bringing the best evidence for practice to bear against nursing care (Lang, 2008). First, the challenge of synthesizing the knowledge available in a manner that is useful to clinicians is critical. Then, computerized information systems are needed to provide clinical decision support at the point of care. Finally, the computer system must collect good clinical data to promote ongoing knowledge development for nursing care of patients and families. Several “intelligent” clinical information systems are in development. These systems translate nursing knowledge into reference materials that can be accessed at the point of care. Further, computer applications are in development that assist nurses to take action and execute patient care based on the best evidence for practice (Lang, 2008; Lang et al., 2006; Staggers & Brennan, 2007).

Professional, Ethical Nursing Practice and New Technologies

Technology has and will continue to transform the healthcare environment and the practice of nursing. Nurses are professionally obligated to maintain competency with a vast array of technologic devices and systems. Baseline informatics competency is required for all nurses to function in the twenty-first century.

Because of the increasing ability to preserve human life with biomedical technology, questions about living and dying have become conceptually and ethically complex. Conceptually, it becomes more difficult to define extraordinary treatment and human life because technology has changed our concepts of living and dying. A source of ethical dilemmas is the use of invasive technologic treatment to provide patients with extraordinary means and to prolong life for patients with limited or no decision-making capabilities. Nurses are concerned with individual patient welfare and the effects of technologic intervention on the immediate and long-term quality of life for patients and their families. Patient advocacy remains an important function of the professional nurse.

Safeguarding patients’ welfare, privacy, and confidentiality is another obligation of nurses. Security measures are available with computerized information systems, but it is the integrity and ethical principles of system end-users that provide the final safeguard for patient privacy. System users must never share the passwords that allow them access to information in computerized clinical information systems. Each password uniquely identifies a user to the system by name and title, gives approval to carry out certain functions, and provides access to data appropriate to the user. When a nurse signs on to a computer, all data and information that are entered or reviewed can be traced to that password. Every nurse is accountable for all actions taken using his or her password. All nurses must be aware of their responsibilities for the confidentiality and security of the data they gather and for the security of their passwords.

Nurse leaders must promote the existence and use of an ethics committee in their institutions and assign knowledgeable nurses to serve on these committees. Nurse managers must ensure that policies and procedures for collecting and entering data and the use of security measures (e.g., passwords) are established to maintain confidentiality of patient data and information. Nurse managers must also be knowledgeable patient advocates in the use of technology for patient care by referring ethical questions to the organization’s ethics committee.

Exercise 11-6

Think about the use of the Internet in health care. How do you use it to look up healthcare information? How would you advise a patient to select appropriate sites?

Conclusion

Biomedical, information, communication, and knowledge technology will form a bond in the future, linking people and information together in a rapidly changing world of health care. With new technology comes the need for a new set of competencies. Nursing participation in designing this exciting future will ensure that the unique contributions of nurses to patient and family health and illness care are clearly and formally represented.

The Solution

—Janis B. Smith

We successfully implemented BCMA over an 11-month period in all our inpatient, emergency, and same-day surgery areas. A systematic review of the literature related to BCMA informed our teams of the potential for nurses to work around the system when it obstructed the process of getting medications to patients on time. In addition, site visits to organizations that had implemented BCMA confirmed the evidence from the literature.

The literature and site visits also demonstrated that hardware reliability does indeed impact nurses’ use of the system. If devices don’t work, nurses work around them to meet patient care needs! We presented our findings and recommendations to nursing leaders and direct care nurses and, in order to provide the most reliable hardware, we opted to hardwire computers and attach Bluetooth bar-code scanners at every patient bedside throughout our organization. In addition, patient care areas have a few mobile computers and scanners to use when patients are not in their rooms. Although this was not an inexpensive option, it ensured that hardware would not be a reason for working around recommended processes for BCMA. Finally, we designed training to systematically address recognized deviations from recommended practice and emphasized the work processes that promoted best practice and patient safety.

Information technology is an essential component of our patient safety program. We report area-specific compliance with BCMA every week to nursing, pharmacy, and informatics leaders who share the information with direct care staff. Most areas comply with work process expectations nearly 95% of the time: surpassing our organizational goal of 90%! More importantly, BCMA has lowered the incidence of adverse drug events in our hospitals and clinics.

***Would this be a suitable approach for you? Why?***

The Evidence

Health Information Technology and Patient Safety

Health information technology (HIT) has the potential to reduce healthcare costs, improve efficiency, and enhance patient care safety and quality. HIT is rapidly evolving and changing how we deliver care, while healthcare reform is simultaneously reshaping the environment in which care is provided. A committee of experts was convened by the Institutes of Medicine in 2011 to review the evidence about the impact of HIT on patient safety and to recommend actions, based on evidence, that safeguard patients in our contemporary technology-rich healthcare environment.

The committee found that specific types of HIT can improve patient safety under the right conditions, but these right conditions may not be easily replicated in all settings. Potential safety benefits and concerns were documented for computerized provider order entry (CPOE), clinical decision support (CDS), bar code confirmation of patient identity and medications, and patient engagement tools. However if not designed and implemented appropriately, HIT may add a layer of complexity to the already complex delivery of health care and lead to unintended consequences. HIT must be designed, implemented, used, and continuously improved to positively enable healthcare quality and safety.

Safely functioning HIT provides easy entry and unlimited retrieval of data, has simple and intuitive user interfaces, supports the clinical workflow of all end-users, and permits seamless system interoperability.

Implications for Practice

Have you used more than one information system during your academic preparation in nursing? If yes, were there advantages in design and implementation that you could detect in one setting or another?

Have you used the same information system in more than one setting? If so, did you detect differences in how the system was designed and implemented in different settings?

If you were to participate on the HIT selection or implementation planning teams in your role as a registered nurse, are you confident you could identify features in the system with potential to either support or threaten patient safety (IOM, 2012)?

What New Graduates Say

• My first position was at a clinic that used a computerized system I’d not used before. I quickly figured out I had to learn it well in order to survive! Take advantage of every opportunity to learn new technology. That way you won’t get so far behind. If you have any downtime, practice using equipment and thinking through the principles associated to a particular device.

• As a newer nurse the idea of having technology as a double-check when administering medications, blood products, breast milk, and so on, via a smart pump and bar-coding technology gives me confidence in what I’m doing.

• As I’m learning and caring for my patients, I appreciate that the system helps me work through next steps based on what I enter.

Chapter Checklist

Nurses are the key personnel in the healthcare system to mediate the interaction among science, technology, and the patient because of their unique holistic viewpoint and the “24/7” role of vigilant healthcare providers who preserve the patients’ humanity, optimal functioning, and promotion of health. The challenge for the profession is to continue to provide patient-centered care in a technologic society that strives for efficiency and cost-effectiveness. Nurse administrators, managers, and staff must provide leadership in managing information and technology to meet the challenge.

• Types of technologies

• Biomedical technology

• Physiologic monitoring

• Diagnostic testing

• Intravenous fluid and medication administration

• Therapeutic treatments

• Information technology

• Knowledge technology

• Information systems

• Meaningful use

• Information systems quality and accreditation

• Information systems hardware

• Wireless communication

• Communication technology

• Informatics

• Patient safety

• Impact of clinical information systems

• Impact on communication

• Impact on patient care documentation

• Impact on medication administration processes

• Safely implementing health information technology

• Future trends and professional issues

• Biomedical technology

• Information technology

• Electronic patient care records

• Data privacy and security

• Communication technology

• Telecommunications

• Informatics

• Knowledge technology

• Professional, ethical nursing practice and new technologies

Tips for Managing Information and Technology

• Create a vision for the future.

• Match your vision to the institution’s mission and strategic plan.

• Learn what you need to know to fulfill the vision.

• Join initiatives that are moving in the direction of your vision.

• Be prepared to initiate, implement, and support new technology.

• Use an automated dispensing system.

• Use biometric technology.

• Use bar-coding systems/bar-code technology.

• Never stop learning, or you will always be behind.

References

Akre, M., Finkelstein, M., Erickson, M., Liu, M., Vanderbilt, L., Billman, G.: Sensitivity of the pediatric early warning score to identify patient deterioration. *Pediatrics*. **125**, 2010, 763–769.

American Association of Colleges of Nursing Strategic Advisory Group for Graduate-Level QSEN Competencies: In *Graduate-level QSEN competencies: Knowledge, skills and attitudes*. 2012, Accessed 15.07.13 at, www.aacn.nche.edu/faculty/qsen/competencies.pdf.

Ammenwerth, E., Mansmann, U., Iller, C., Eichstadter, R.: Factors affecting and affected by user acceptance of computer-based nursing documentation: Results of a two-year study. *Journal of the American Medical Informatics Association: JAMIA*. **10**, 2003, 69–84.

Ash, J.S., Berg, M., Coiere, E.: Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *Journal of the American Medical Informatics Association: JAMIA*. **11**, 2004, 104–112.

Ash, J.S., Sittig, D.F., Poon, E.G., Guappone, K., Campbell, E., Dykstra, R.H.: The extent and importance of unintended consequences related to computerized provider order entry. *Journal of the American Medical Informatics Association: JAMIA*. **14**(4), 2007, 415–423.

Bakken, S., Cook, S., Curtis, L., Desjardins, K., Hyun, S., Jenkins, M., et al.: Promoting patient safety through informatics based nursing education. *International Journal of Medical Informatics*. **73**, 2004, 581–589.

Ball, M., Weaver, C., Abbot, P.: Enabling technologies promise to revitalize the role of nursing in an era of patient safety. *International Journal of Medical Informatics*. **69**, 2003, 29–38.

Benham-Hutchins, M.: Frustrated with HIT? Get involved!. *Nursing Management*. **40**(1), 2009, 17–19.

Bonzheim, K.: Process and workflow improvements through technology adoption. 2006, Healthcare Information and Management Systems Society, Chicago, IL.

Breslow, M.J.: Remote ICU care programs: Current status. *Journal of Critical Care*. **22**, 2007, 66–76.

Considine, K., Botti, V.: Who, when and where? Identification of patients at risk of an in-hospital adverse event: Implications for nursing practice. *International Journal of Nursing Practice*. **10**, 2004, 21–31.

Cronenwett, L., Sherwood, G., Pohl, J., Barnsteiner, J., Moore, S., Sullivan, D., et al.: Quality and safety education for advanced nursing practice. *Nursing Outlook*. **57**, 2009, 338–348.

Delaney, C.: Nursing and informatics for the 21st century. *Creative Nursing*. **2**, 2007, 4–6.

Drucker, P.: Post-capitalist society. 1993, Harper Business Publishers, New York.

Ebright, P.R., Patterson, E.S., Chalko, B.A., Render, M.L.: Understanding the complexity of registered nurse work in acute care settings. *Journal of Nursing Administration*. **33**, 2003, 630–638.

Frankel, D.J., Cowie, M., Daley, P.: Quality benefits of an intensive care clinical information system. *Critical Care Medicine*. **31**, 2003, 120–125.

Franklin, B.D., O’Grady, P., Donyai, K., Jacklin, A., Barber, N.: The impact of a closed-loop electronic prescribing and administration system on prescribing errors, administration errors and staff time: A before-and-after study. *Quality & Safety in Health Care*. **16**, 2007, 279–284.

Hannah, K.J., Ball, M.J.: Introduction to nursing informatics. 4th ed., 2011, Springer-Verlag, London; New York.

Harrison, P.: In *Alarm fatigue still top technology hazard for 2103*. May 30, 2013, *Medscape,*http://www.medscape.com/viewarticle/805050.

HIMSS Analytics Report: In *Quality and safety linked to advanced information technology enabled processes*. 2012, Retrieved February 12, 2012 from, www.himss.org/content/files/thomsonreuterswhitepaperfinal0412.pdf.

Hunter, K.M.: Nursing informatics theory. In V.K. Saba, K.A. McCormick (Eds.): *Essentials of computers for nurses: Informatics for the new millennium*. 2001, McGraw-Hill, New York, 179–190.

Institute for Safe Medication Practices (ISMP): ADC survey shows some improvements, but unnecessary risks still exist. *Safety Briefs*. **13**, 2008, 1–2.

Institute of Medicine (IOM): In *The future of nursing: Leading change, advancing health*. 2011, National Academy Press, Washington, DC.

Institute of Medicine (IOM), Committee on Patient Safety: In *To err is human: Building a safer health care system*. 2000, The National Academies Press, Washington, DC.

Institute of Medicine (IOM), Committee on Patient Safety and Health Information Technology: In *Health IT and patient safety: Building safer systems for better care*. 2012, The National Academies Press, Washington, DC.

Institute of Medicine (IOM), Committee on Quality Health Care in America: In *Crossing the quality chasm: A new health system for the 21st century*. July 2001, National Academy Press, Washington, DC.

Institute of Medicine (IOM), Committee on the Work Environment for Nurses and Patient Safety: Keeping patients safe: Transforming the work environment of nurses. 2004, The National Academies Press, Washington, DC.

Kaplan, B.: Evaluating informatics applications: Some alternative approaches. *International Journal of Medical Informatics*. **64**(1), 2001, 39–56.

Kaplan, B., Harris-Salamone, K.D.: Health IT success and failure: Recommendations from the literature and an AMIA workshop. *Journal of the American Medical Informatics Association: JAMIA*. **16**, 2009, 291–299.

Koppel, R., Wetterneck, T., Telles, J.L., Karsh, B.T.: Workarounds to barcode medication administration systems: Their occurrences, causes, and threats to patient safety. *Journal of the American Medical Informatics Association: JAMIA*. **15**, 2008, 408–423.

Korst, L., Eusebio-Angeja, A., Chamorro, T., Aydin, C., Gregory, K.: Nursing documentation time during implementation of an electronic medical record. *Journal of Nursing Administration*. **33**, 2003, 24–30.

Kossman, S.P., Scheidenhelm, S.L.: Nurses’ perceptions of the impact of electronic health records on work and patient outcomes. *CIN: Computers, Informatics, Nursing*. **26**, 2008, 69–77.

Krichbaum, K., Diemert, C., Jacox, L., Jones, A., Koenig, P., Mueller, C., et al.: Complexity compression: Nurses under fire. *Nursing Forum*. **42**, 2007, 86–94.

Lang, N.M.: The promise of simultaneous transformation of practice and research with the use of clinical information systems. *Nursing Outlook*. **56**, 2008, 232–236.

Lang, N.M., Hook, M.L., Akre, M.E., Kim, T.Y., Berg, K.S., Lundeen, S.P.: Translating knowledge-based nursing into referential and executable applications in an intelligent clinical information system. In C. Weaver, C. Delaney, P. Webber, R. Carr (Eds.): *Nursing and informatics for the 21st century*. 2006, Healthcare Information and Management Systems Society (HIMSS), Chicago, 291–304.

Larrabee, J.H., Boldreghini, S., Elder-Sorrells, K., Turner, Z.M., Wender, R.G., Hart, J.M., et al.: Evaluation of documentation before and after implementation of a nursing information system in an acute care hospital. *Computers in Nursing*. **19**, 2001, 56–65.

Laws, D., Amato, S.: Incorporating bedside reporting into change of shift report. *Rehabilitation Nursing*. **35**(2), 2010, 70–74.

Malashock, C., Smith-Shull, S., Gould, D.A.: Effect of smart infusion pumps on medication errors related to infusion device programming. *Hospital Pharmacy*. **39**(5), 2004, 460–469.

Malbrain, M.L., Chiumello, D., Pelosi, P., Bihari, D., Innes, R., Ranieri, V.M., et al.: Incidence and prognosis of intraabdominal hypertension in a mixed population of critically ill patients: A multiple-center epidemiological study. *Critical Care Medicine*. **33**, 2005, 315–322.

Malloch, K.: The electronic health record: An essential tool for advancing patient safety. *Nursing Outlook*. **55**, 2007, 159–161.

Marin, H.: Improving patient safety with technology. *International Journal of Medical Informatics*. **73**, 2004, 543–546.

McBride, A.: Nursing and the informatics revolution. *Nursing Outlook*. **53**, 2005, 183–191.

Mekhjian, H.S., Kumar, R.R., Kuehn, L., Bentley, T.D., Teater, P., Thomas, A., et al.: Immediate benefits realized following implementation of physician order entry at an academic medical center. *Journal of the American Medical Informatics Association*. **9**(5), 2002, 529–539.

Myers, M.A., Reed, K.D.: The virtual ICU (vICU): A new dimension for critical care nursing practice. *Critical Care Nursing Clinics of North America*. **20**, 2008, 435–439.

National League for Nursing (NLN): Position statement: Preparing the next generation of nurses to practice in a technology-rich environment—An informatics agenda. 2008, Retrieved March 2, 2010 from, www.nln.org.

Parker, P.J.: One nurse informatics specialist views the future technology in the crystal ball. *Nursing Administration Quarterly*. **29**(2), 2005, 123–124.

Pevtzow, L.: New guidelines to reduce alarm fatigue. April 16, 2013, *Medscape,*http://www.medscape.com/viewarticle/782597.

Reason, J.: Combating omission errors through task analysis and good reminders. *Quality & Safety in Health Care*. **11**, 2002, 40–44.

Scholes, M., Barber, B.: Towards nursing informatics. In D.A.D. Lindberg, S. Kaihara (Eds.): *MEDINFO: 1980*. 1980, North-Holland, Amsterdam, Netherlands, 7–73.

Sensmeier, J.: Deep impact: Informatics and nursing practice. *Nursing Management IT Solutions Supplement*. 2008, 2–6, September.

Smith, J.B., Burnes Bolton, L.: What is meaningful use and what are the implications for the future of health care. *Nurse Leader*. **11**, 2013, 20–21.

Snyder-Halpern, R., Corcoran-Perry, S., Narayan, S.: Developing clinical practice environments supporting the knowledge work of nurses. *Computers in Nursing*. **19**(1), 2001, 17–23.

Staggers, N., Brennan, P.F.: Translating knowledge into practice: Passing the hot potato!. *Journal of the American Medical Informatics Association: JAMIA*. **14**, 2007, 684–685.

Stead, W.W., Bird, W.P., Califf, R.M., Elchlepp, J.G., Hammond, W.E., Kinney, T.R.: The IAIMS at Duke University Medical Center: Transition from model testing to implementation. *MD Computing*. **10**, 1993, 225–230.

In Stead, W.W., Lin, H.S. (Eds.): *Computational technology for effective health care: Immediate steps and strategic directions*. 2009, National Academies of Science, Washington, DC.

The Joint Commission (TJC): In *Sentinel event alert: Safely implementing health information and converging technologies*. 2008, Retrieved September 24, 2009, from, www.jointcommission.org/SentinelEvents/SentinelEventAlert/sea\_42.htm.

The Joint Commission (TJC): In *Sentinel event alert: Medical device alarm safety in hospitals*. 2013, Retrieved June 6, 2013 from, www.jointcommission.org/assets/1/18/SEA\_50\_alarms\_4\_5\_13\_FINAL1.PDF.

The Joint Commission (TJC): In *TJC accreditation manual e-dition*. 2013, Retrieved May 21, 2013, from, https://e-dition.jcrinc.com/MainContent.aspx.

The TIGER Initiative: Informatics competencies for every practicing nurse. 2010, Retrieved July 14, 2013 from, www.tigersummit.com/uploads/3.Tiger.Report\_Competencies\_final.pdf.

Trossman, S.: The documentation dilemma: Nurses poised to address paperwork burden. *The American Nurse*. **33**, 2001, 1, 9,18.

Vidal, M.G., Ruiz Weisser, J., Gonzalez, F., Toro, M.A., Loudet, C., Balasini, C., et al.: Incidence and clinical effects of intra-abdominal hypertension in critically ill patients. *Critical Care Medicine*. **36**, 2008, 1823–1831.

Warren, J., Connors, H.: Health information technology can and will transform nursing education. *Nursing Outlook*. **55**, 2007, 58–60.

Westbrook, J., Duffield, C., Li, L., Creswick, N.: How much time do nurses have for patients? A longitudinal study quantifying hospital nurses’ patterns of task time distribution and interactions with health professionals. *BMC Health Services Research*. **11**, 2011, 319.

Wood, S.: In *“Alarming” use of unnecessary ECG monitors, ubiquitous*. March 9, 2013, possibly harmful. *Medscape,*http://www.medscape.com/viewarticle/780537.

Suggested Readings

American Nurses Association: Nursing informatics: Practice scope and standards of practice. 2008, Nursesbooks.org, Silver Spring, MD.

Englebardt, S.P., Nelson, R.: Health care informatics: An interdisciplinary approach. 2005, Mosby, St Louis.

Hebda, T.L., Czar, P.: Handbook of informatics for nurses & healthcare professionals. 2013, Pearson, Boston.

McGonigle, D.: Nursing informatics. 2008, Jones & Bartlett Publishing, Boston.

Saba, V., McCormick, K.A.: Essentials of nursing informatics. 2011, McGraw-Hill Medical, New York.

Weaver, C., Delaney, C., Webber, P., Carr, R.: Nursing and informatics for the 21st century. 2006, Healthcare Information and Management Systems Society (HIMSS), Chicago.

Additional References

Aiken, L., Clark, S., Sochalski, J., Silber, J.: Hospital nurse staffing and patient mortality, nurse burnout. *JAMA*. **288**, 2002, 1987–1993.

American Nurses Association: Registered Nurse Save Staffing Act of 2010 (S.3491 / H.R.5527). 2010, Retrieved from, http://safestaffingsaveslifes.org/whatisANADoing/FederalLegislation.aspx.

Douglas, K.: The human side of staffing. *Nursing Economic$*. **28**, 2010, 56–62.

Douglas, K.: What every nurse executive should know about staffing and scheduling technology initiatives. *Nursing Economic$*. **29**, 2011, 273–275.

Eck-Birmingham, S.: Evidence based staffing: The next step. *Nurse Leader*. **8**, 2010, 24–35.

Harper, E.M.: Staffing based on evidence: Can health information technology make it possible?. *Nursing Economics*. **30**, 2012, 262–267.

Hyun, S., Bakken, S., Douglas, K., Stone, P.W.: Evidenced-based staffing: Potential roles for informatics. *Nursing Informatics*. **26**, 2008, 159–168.

Institute of Medicine: Health IT and patient safety: Building safer systems for patient safety. 2012, The National Academies Press, Washington D.C.

Locsin, R.C.: Technological competency as caring in nursing: A model for practice. 2005, Sigma Theta Tau International, Indianapolis, IN.

 (Yoder-Wise 187)

Yoder-Wise, Patricia. *Leading and Managing in Nursing, 6th Edition*. Mosby, 2015. VitalBook file.

The citation provided is a guideline. Please check each citation for accuracy before use.