CHAPTER 6 Healthcare Information Systems

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After completing this chapter, you should be able to:

* 1. Identify the various types of information systems used within healthcare institutions.
* 2. Define the terms *healthcare information system, hospital information system, clinical information system, nursing information system, physician practice management system, long-term care information system, home care information system*, and *administrative information system*.
* 3. Explain the functions of a nursing information system.
* 4. Differentiate between the nursing process and critical pathways/protocol approaches to the design of a nursing system.
* 5. Review the key features and impacts on nursing and other healthcare professionals associated with order entry, laboratory, radiology, and pharmacy information systems.
* 6. Describe the functions of client registration and scheduling, and coding systems.
* 7. Explain the purpose of decision support and expert systems.
* 8. Identify ways that mobile devices such as personal digital assistants, tablet computers, and iPods can improve the utility of healthcare information systems.

An [**information system**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid29869) can be defined as the use of computer hardware and software to process data into information to solve a problem. The terms [**healthcare information system**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid29723) and [**hospital information system (HIS)**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid29793) both refer to a group of systems used within a hospital or enterprise that support and enhance healthcare. The HIS comprises two major types of information systems: clinical information systems and administrative information systems. [**Clinical information systems (CISs)**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid29117) are large, computerized database management systems that support several types of activities that may include provider order entry, result retrieval, documentation, and decision support across distributed locations.

Clinicians use these systems to access client data that are used to plan, implement, and evaluate care. CISs may also be referred to as *client care information systems*. Some examples of CISs include nursing, laboratory, pharmacy, radiology, medical information systems, emergency department systems, physician practice management systems, and long-term and home care information systems. [**Administrative information systems**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid28824) support client care by managing financial and demographic information and providing reporting capabilities. This category includes client management, financial, payroll and human resources, and quality assurance systems. Coding systems use clinical information to generate charges for care. [**Figure 6–1**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7151) shows the relationships between various components of a hospital information system.

Clinical and administrative information systems may be designed to meet the needs of one or more departments or functions within the organization. In recent years the trend has been to adopt vendor-based solutions with little, if any, customization, allowing implementation to occur more quickly. Either clinical or administrative systems can be implemented as standalone systems, or they may work with other systems to provide information sharing and seamless functionality for the users. Any one healthcare enterprise may use one or several of the clinical and administrative systems but may not use all of them. Increasingly, organizations are looking at the need to improve productivity, improve safety, increase the quality of care, meet regulatory and reimbursement requirements, and reduce costs across the enterprise. Information technology is seen as the means to achieve these ends through the application of evidence-based care, improved work flow, and better management of resources. Patient safety initiatives also require facilities to establish a culture of safety in which problem areas are identified, the culture is measured periodically, findings are shared, and feedback for change is solicited (Smetzer & Navarra [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8087), p. 136).

CLINICAL INFORMATION SYSTEMS

Although many CISs are designed for use within one hospital department, clinicians and researchers from several areas use the data collected by each system. For example, the nurse documents client allergies in the initial assessment. The physician, the pharmacist, the dietician, and the radiologist can then use these data during the client’s hospital stay. The goal of CISs is to allow clinicians to quickly and safely access information, order appropriate medications and treatments, and implement cost-effective, evidence-based care while avoiding duplicate services. Several tools help clinicians to achieve these goals. These include electronic health records, clinical decision support systems, bedside medication administration using positive patient identification, computerized provider order entry (CPOE), patient surveillance, and the clinical data warehouse (CDW). While large teaching hospitals generally have more monies to invest in the information technology, all healthcare providers are now looking at information technology solutions in order to meet Meaningful Use requirements and realize HIT benefits. Mobile and wireless technology used with CISs allow information entry and retrieval at the point of care or wherever it is needed by the healthcare professional. This is best seen by the healthcare professional who can view client lab results while walking or at the point of care which enhances worker productivity because it eliminates the need to walk back to a central location to view test results, and it improves client service because treatments can be ordered and initiated in a more timely fashion. Internet technology also changes the way that users interact with CISs. This capability allows physicians to view client test results from home, office, the golf course, or at the mall. Despite the fact that the technology exists to permit this type of access, not all facilities can provide it at this time. The following descriptions of CISs address those that are most frequently seen in the hospital setting.

FIGURE 6–1 Relationship of the healthcare information system components

Nursing Information Systems

According to Hendrickson ([**1993**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7991)) a [**nursing information system**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30301) supports the use and documentation of nursing processes and activities, and provides tools for managing the delivery of nursing care. An effective nursing information system must accomplish two goals:

* • Support the way that nurses function, allowing them to view data, collect necessary information, provide quality client care, and document the client’s condition and the care that was given.
* • Support and enhance nursing practice through improved access to information and tools such as online literature databases, drug information, and hospital policy and procedure guidelines.

Consideration of these two goals in the selection and implementation of a system ensures that it will benefit nursing. The two main approaches to nursing care and documentation using automated information systems have been the *nursing process approach* and the *critical pathway*, or *protocols*, approach. The traditional nursing process approach allows documentation of nursing care using well-established formats such as admission assessments, problem lists, and care plans. Ideally this approach incorporates [**standardized nursing languages (SNLs)**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30863) accepted by the American Nurses Association because SNLs provide a common language across the discipline of nursing that allows all nurses to describe nursing problems, treatments, and outcomes in a manner that is universally understood. SNLs facilitate data collection and research that can be replicated and shared across all of nursing. The advantages of using an information system are listed in [**Box 6–1**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7199).

***Nursing Process Approach***

The nursing process approach to automated documentation often uses the nursing diagnosis and traditional paper processes long used by nurses as the organizational framework. Components in this approach include:

BOX 6–1 Advantages of an Information System

* • Better access to information
* • Enhanced quality of documentation through prompts
* • Improved quality of client care
* • Increased productivity
* • Improved communications
* • Reduced errors of omission
* • Reduced hospital costs
* • Increased employee satisfaction
* • Compliance with agency regulations
* • Common clinical database
* • Improved client perception of care
* • Enhanced ability to track records
* • Enhanced ability to recruit/retain staff
* • Improved hospital image
* • Improved mandatory reporting capability
* • *Documentation of nursing admission assessment and discharge instructions*. A menu-driven approach ensures capture of essential information. A [**menu**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30166) lists related commands that can be selected from a computer screen to accomplish a task. For example, the menu may include selections such as past medical history, advanced directives, organ donation status, psychosocial history, medications, and review of body systems. This approach also helps to ensure that all necessary information is covered in the client’s discharge instructions, including follow-up appointments and diagnostic studies; diet and activity restrictions; wound care; and medication information such as drug names, instructions for administration, and common side effects that the client should report. The system should generate printed copies of these instructions for clients to review on discharge and for their use at home, as well as for use by the Home Health staff.
* • *Generation of a nursing worklist that indicates routine scheduled activities related to the care of each client*. These activities can be grouped according to scheduled time or skill level.
* • *Documentation of discrete data or activities such as vital signs, weight, and intake and output measurements*. The automation of this type of data promotes accuracy and allows the data to be readily available to all care providers at any time.
* • *Documentation of routine aspects of client care, such as bathing, positioning, blood glucose measurements, notation of dietary intake, and/or wound care in a flowsheet format*.
* • *Standardized care plans that the nurse can individualize for clients as needed*. This feature saves time yet allows flexibility to address the client’s needs while promoting quality care.
* • *Documentation of nursing care in a progress note format*. The nurse may accomplish this through narrative charting, charting by exception, or flowsheet charting. Regardless of the method used, automated documentation can improve the overall quality of charting by prompting the nurse with predefined selections. [**Box 6–2**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7282) describes three of these traditional formats and some typical automation approaches.
* • *Documentation of medication administration*. This multistep feature may be performed through the information system, but increasingly it is done via a separate medication administration application. Worklists associated with this feature specify administration times and medications for each patient; the nurse can use the worklist for preparation and administration of medications with subsequent documentation through the system.

BOX 6–2 Automation of Traditional Nursing Documentation Methods

Many forms of nursing documentation have been automated by various nursing information systems. Some of these formats are listed next.

* • **Narrative charting.** Traditionally, nurses complete charts using narrative text. In a nursing information system, this may be accomplished using free text entry or menu selections.
* • **Charting by exception.** Client-specific documentation addresses only the client’s exceptions to normal conditions or ranges. Automated documentation should provide all normal standards and allow the nurse to easily document any exception observed. This may involve menu selections or free text entry.
* • **Flowsheet charting.** Routine aspects of care are documented in tabular form. This format is most effective when presented in a personal computer–based graphical user interface. A pointing device such as a mouse is used to make menu selections or text entries. One form of flowsheet charting is the automation of medication administration records.
* • **Standardized nursing languages.** This approach uses NANDA nursing diagnoses as well as the Nursing Interventions Classification and Nursing Outcomes Classification languages. It removes the ambiguity of meaning found in other documentation systems.

Recent initiatives to improve patient safety and decrease medication errors call for the use of barcode medication administration systems. While these are not considered to be a part of a nursing documentation system, barcode systems are designed to prevent common medication administration errors at the bedside, document medication administration, and capture charges. These systems require a nurse to scan the barcodes found on his or her identification, the patient’s identification bracelet, and on all prescription medications during the medication administration process. These systems are designed to help the busy nurse to ensure that the right medication is given in the correct dosage and form at the correct time for the right patient. Barcoding systems often include warnings for high-risk drugs, medications with sound-alike names, dosage discrepancies, and maximum dosages.

***Critical Pathway or Protocols***

The critical pathway or protocol approach to nursing documentation is the second approach used in automated nursing information systems and it is often used in a multidisciplinary manner, with many types of care providers accessing the system for information and to document care. Nurses, nursing or patient care assistants, dietitians, social workers, respiratory therapists, physical and occupational therapists, case managers, and physicians all use these systems for documentation. Critical pathway systems include the following features:

* • *The nurse, or other care provider, can select one or more appropriate critical pathways for the client*. If more than one path is selected, the system should merge the paths to create one “master” path or protocol.
* • *Interaction with physician orders*. Standard physician order sets can be included with each critical pathway and may be automatically processed by the system.
* • *Tracking of protocol variances*. The system should identify variances to the anticipated outcomes as they are charted and provide aggregate variance data for analysis by the providers. This information can be used to fine-tune and improve the critical pathways, thereby contributing to improved client outcomes.

Despite the many reasons to establish a nursing information system and the fact that nurses constitute the majority of workers in healthcare, most systems today are designed for use by all clinicians and incorporate features discussed here.

Monitoring Systems

[**Monitoring systems**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30221) are devices that automatically monitor biometric measurements in critical care and specialty areas, such as cardiology and obstetrics. These devices may send information to the nursing documentation system. For example, a monitoring system would directly enter measurements such as blood pressures, eliminating the need for the nurse to enter these data manually. Another example may be seen with blood glucose monitors that send client readings to the laboratory system for display with other laboratory tests. [**Box 6–3**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7331) describes some additional features of monitoring systems.

BOX 6–3 Some Common Features of Monitoring

* • **Alarms alerting the nurse of significant abnormal findings.** Sophisticated systems provide different alarms indicating various abnormalities. For example, the nurse may be able to hear a specific alarm sound that indicates which cardiac arrhythmia the client is experiencing.
* • **Portable monitoring systems.** These systems allow easy transportation of the client throughout the facility without loss of data or functionality.
* • **Records of past abnormal findings.** The system maintains a record of all past abnormal findings during this monitoring episode. The system allows the user to find trends in data using graphical displays and to focus on specific details.
* • **Download capabilities.** The system may be able to transfer patient data to a separate system in another facility to provide a continuous patient record.

Order Entry Systems

With [**order entry systems**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30387), orders for medications and treatments are entered into the computer and are directly transmitted to the appropriate areas such as the pharmacy, laboratory, radiology, social service, or another area. The preferred method is direct entry of orders by the physician, nurse practitioner, physical therapist, or other provider because this eliminates issues related to illegible handwriting and transcription errors, checks orders for accuracy and completeness, speeds the implementation of ordered diagnostic tests and treatment modalities, decreases adverse drug events, enhances staff productivity, saves money, promotes safety, and improves outcomes when used in conjunction with evidence-based practices (Dentzer [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7971); Leapfrog hospital survey results [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8013); Powell [**2011**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8057); Standardize order sets for improved care [**2010**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7944)). This process is known as computerized physician, provider, or prescriber order entry (CPOE). CPOE represented a major initiative on the part of the Institute of Medicine and Leapfrog Group to improve the quality of care and reduce medication errors (Conn [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7961)). While most CPOE is found in inpatient settings, its benefits apply to outpatient and ambulatory settings as well, where it also plays a critical role in the prevention of prescription errors. The safety of CPOE systems is enhanced through the incorporation of built-in reminders and alerts that help the prescriber to select the most appropriate diagnostic test or medication for a particular patient as well as the appropriate dose and form. Challenges to the implementation of CPOE include buy-in by busy clinicians, significant changes to work processes, difficult system sign-on, limited system access or response time, funding constraints, inadequate access to clinical data to support the expert decision-making features of CPOE, and the perception by many physicians that CPOE affords them few advantages. Successful CPOE implementation requires significant expertise in healthcare processes, information technology, and change management, as well as careful planning and building that includes input from nurses, pharmacists, and other stakeholders. At present Meaningful Use requirements for hospitals constitute a major driver for the adoption of CPOE (CMS [**2010**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7944)). In some settings, transcription of physician orders into the clinical information system is still done by a nurse or by ancillary personnel. When entries are made by ancillary personnel, nurses are responsible for ensuring that entries are correct.

Entry of an order into a clinical information or order entry system alerts all departments to carry out orders. For example, when a physician orders a barium enema, the order entry system can automatically notify the dietary department to hold the client’s breakfast, the pharmacy to send the appropriate medications, and the radiology department to schedule the test. These systems prompt the clinician to provide the information necessary for carrying out the order.

Another feature of an order entry system is duplicate checking. When an order is entered, the system checks to see if a similar order has been placed within a specified time frame. If this is the case, the system can alert the user with a message, or automatically combine the two orders, permitting only one execution of the order.

The order entry system can reflect the current status of each order. For example, the status may be listed as pending, complete, or canceled. This allows the user to see a comprehensive list of the client’s orders at any point in time. It can also afford a mechanism for the entry of charges for a procedure once it has been completed.

One mechanism that is used in some order entry systems uses rules-based or knowledge-based programming. Rules provide guidelines to assist physicians to select the preferred and most cost-effective medication along with the best route and dose for a particular patient problem. Rules can also provide prompts for when patients should be seen next and diagnostic tests that should be performed. These automated reminders help to improve the quality of care by reducing reliance upon memory, providing evidence-based practice guidelines, and informing the prescriber when a more cost-effective oral medication is available in lieu of an intravenous form (Chazard et al, [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7948); Matsuura & Weeks [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8028)).

Despite the many advantages associated with CPOE, it may also introduce new problems and errors related to new work processes (Ash et al. [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7926); Bradley, Steltenkamp, & Hite [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7932); Cornish, Etchells, & Knowles, [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7968); Moniz [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8043); Weant, Cook, & Armistead [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8103)). These unintended consequences may include an increase in medication errors even if the level of harm related to errors does not increase. Pharmacists can help identify potential problem areas and needed modifications prior to implementation. Some examples include reminders or alerts to:

* • Prescribe laxatives for patients prescribed opioids
* • Order drug levels for therapeutic levels
* • Avoid lapses in medications
* • Avoid prescribing drugs that are contraindicated for certain medical conditions such as impaired renal function

Pre-implementation planning should address unintended consequences. It is important not to underestimate the time required for training or the impact of CPOE on nursing practice as nurses are called upon both to assist physicians struggling to learn the system and to execute more verbal orders by physicians unwilling to use the system. Verbal orders are subject to errors, defeating the safety checks built into CPOE. Nursing leaders must provide sufficient resources to manage the additional workload as staff and physicians make the transition to CPOE and ensure that no verbal orders will be accepted except during emergency situations.

Laboratory Systems

[**Laboratory information systems (LISs)**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30019) can provide many benefits, including a shorter turnaround time for results; prevention of duplicate testing; decreased likelihood of human error; and identification of abnormal results according to age, sex, and hospital standards. Systems have the capability to alert providers when new or stat test results are back or values are critical (Goedert [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7984)). Additional features can include the automatic entry of repeating tests at the time of the original order. An example might include the order “troponins x3,” which would automatically schedule the first troponin level, with the second 8 hours later and the third level 8 hours after the second and which would subsequently bundle serial tests into one claim for reimbursement. Systems may also allow providers to enter orders without leaving the patient’s electronic record. In addition, microbiology culture and sensitivity testing can provide treatment suggestions for the physician.

Automatic generation of specimen labels should occur when an order is placed either directly into an LIS or passed to an order entry system. Labels may include client demographic identifiers, the name of laboratory studies to be performed, and any special instruction for handling, such as “place on ice.” Labels may be configured to print immediately at the client location for stat or nurse-collected specimens or in the laboratory in batch mode for laboratory-collected specimens. Batch mode allows the labels to be printed in groups for standard collection times, either on demand or at predefined times.

When specimens are processed by the laboratory instrumentation, the results are automatically transmitted to the LIS. The results can be viewed directly from the LIS or transmitted to another information system, such as the nursing or medical information system. Laboratory values are available immediately on completion of the testing process. If desired, printed paper copies of the results may be produced immediately at predefined locations, such as the nursing unit or physician’s office, or can be printed in cumulative format for permanent chart copies.

Another feature of many laboratory systems is automatic client billing for tests completed. This information may be communicated to the client billing system.

Yet another feature seen in many laboratory systems is the ability to integrate results collected at the bedside using portable devices. This is seen with the performance of blood glucose monitor tests in the clinical area. Results are then sent to the laboratory system immediately or sent when the blood glucose monitor is docked. This affords clinicians an integrated view of patient results and the ability to compare glucose readings taken at the bedside with glucose readings from blood specimens sent to the laboratory. While this feature is widely used and appreciated more commonly, the demand is to have LIS results available at the bedside or via mobile devices such as personal digital assistants (PDAs) in which results are passed either through the laboratory or clinical information system to the PDA for review.

Another feature of some laboratory systems is the ability to use rules-based testing. A [**rule**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30713) is a predefined function that generates a clinical alert or reminder. [**Arden syntax**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid28879) is the standard language used in the healthcare industry for writing rules. A rules-based LIS could automatically order a second test based on the results of an initial test. For example, if a client has an abnormal complete blood cell count value, the system will perform a differential, which is a more specific second test. Rules-based testing could also eliminate unnecessary testing after several consecutive normal results have been obtained, as when physicians order daily laboratory work. These measures save costs and the staff time of assessing the need for and performing the tests. The incorporation of rules-based technology may require the user to enter all of the information needed for specific tests. An example is weight for a creatinine clearance test to determine whether the client’s renal function falls within the normal range. Another example of rules-based technology is seen when labels are printed with collection instructions such as tube color, amount needed, and directions such as “place on ice.” Rules can also be used to limit tests to those covered by Medicare or other third-party payers or to determine how and where test results will be sent (Rogoski [**2003**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8069)).

Laboratory systems also have the potential to provide more meaningful information such as genetic predisposition toward certain diseases based on information that already exists in the hospital or laboratory database, information that can be useful in the diagnosis and procurement of payment from third-party payers (Rogoski [**2003**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8069)).

One traditionally weak area in the collection and processing of laboratory results is patient identification. Handwritten labels may be illegible for reasons of poor handwriting or spills. The use of barcoding in conjunction with an LIS to track specimens helps to eliminate this type of problem. Barcodes are either printed directly onto collection labels or affixed at the time of processing to help improve specimen tracking. This process results in improved patient safety and productivity.

Although many institutions are moving toward a paperless record, it has been common practice for staff and students to print out copies of laboratory findings for their personal reference and to communicate to other staff. The ability to send results directly to secure mobile devices helps to ensure the privacy of health information because it eliminates the need for large numbers of printouts and the need to fax sensitive information.

Radiology Systems

A [**radiology information system (RIS)**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30575) provides scheduling of diagnostic tests, communication of clinical information, generation of client instructions and preparation procedures, transcription of results and impressions, and file room management such as tracking of film location. Orders may be entered directly into the radiology system or transmitted from an order entry system. Radiology clerical staff use order information to schedule patients for testing. Once the test is complete, the radiologist interprets the findings and dictates a report. This report can be transcribed using the radiology system or a separate transcription system. The radiology system generates billing information that can be sent to the billing system. The reports are then stored within the radiology system. They may also be faxed to the physician’s office or viewed through the clinical or nursing information systems.

One example of how a radiology system might be used is seen with magnetic resonance imaging (MRI) orders. As the first step in placing an MRI order, the system generates a questionnaire that asks questions pertinent to the MRI procedure. For example, it asks whether the client is cooperative or claustrophobic, and if there are any metal foreign bodies related to previous surgeries or injuries. The nurse reviews these questions with the client, then enters the answers to each question and the order requested into the system. A radiologist reviews the order request and the questionnaire answers, and determines if the client is appropriate for testing. This procedure allows scheduling of appropriate clients only, and eliminates the time-consuming and costly scheduling and attempted testing of inappropriate clients.

More recent developments in RIS include digital, filmless images as a replacement for traditional radiology films. These [**picture archiving and communications systems (PACS)**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_040.xhtml#eid30469) allow images to be electronically transmitted and viewed using sophisticated, high-resolution monitors. The enhanced quality of these images over traditional films may result in fewer repeat procedures and improved diagnostic capability. Digital filmless imaging is also an integral component in the evolution of the electronic client record. The use of this technology may allow hospitals to do away with radiology images captured on film. This reduces or eliminates the large expense of radiology films, as well as handling and storage of the x-rays. In addition, PACS allows the physician to view the image on a computer screen within seconds after the completion of the procedure. Another benefit of a PACS is that more than one physician can view an image simultaneously in multiple locations. While special workstations are available for PACS, images can be viewed on any computer albeit the resolution may not be as good.

Other benefits of this technology are seen when these images are transmitted to high-acuity areas, such as emergency departments and intensive care units, where quick turnaround and immediate availability of images are critical to providing optimum client care. The use of this technology can facilitate client care in remote rural healthcare facilities where a radiologist may not be on-site. Images can be transmitted to a major medical center for evaluation by radiologists and other physicians. Benefits are realized in terms of cost, because it is not necessary to staff a radiologist, and improved client care when a radiologist is on staff but not available.

Implementation of a PACS system should include consideration of the following issues:

* • *Ability to exchange data with the RIS*.
* • *Systems standards base*. The system should be operable without proprietary software that makes it difficult to use or upgrade.
* • *Access to previous studies*. On-demand access to all prior client studies is preferable.
* • *Required infrastructure*. Can the system be used with existing computers and the electronic medical record system?
* • *System performance*. Are records available quickly and of sufficient quality for diagnostic purposes?

Pharmacy Applications and Systems

The inpatient pharmacy process is complex and the source of many medication errors given the large number of drugs on the market, sound-alike names, high patient acuity levels, and large number of medication orders processed. The National Coordinating Council for Medication Error Reporting and Prevention ([**2005**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8050), p. 4), a group comprised of more than 20 national organizations, including the Food and Drug Administration (FDA), defined a medication error as “any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer.” Several other groups have also worked on strategies to reduce errors. In 2001 the Patient Safety Task Force was formed under the Department of Health and Human Services’ Quality Improvement Initiative to improve data collection on patient safety. The lead agencies in the Patient Safety Task Force included:

* • FDA
* • Centers for Disease Control and Prevention
* • Centers for Medicare & Medicaid Services
* • Agency for Healthcare Research and Quality

The FDA also reviews reports that come from drug manufacturers through the agency’s safety information and adverse event reporting program, MedWatch. The FDA now rejects all applications for similar drug names by using a computer program that searches for similar sounding names. The Institute for Safe Medication Practices accepts reports from consumers and health professionals using collected information to publish a consumer newsletter on medication errors. Hospitals report medication errors via the national MedMARX error-reporting program.

Combining pharmacy information systems with barcode technology, as described in [**Box 6–4**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7466), can drastically reduce medication errors. Information systems can provide checkpoints at each phase of the medication ordering and administration process using evidence-based medication selection and dosing guidelines. Other checkpoints may include alphabetizing drugs by chemical name; decreasing the amount of floor stock so that staff are less likely to accidentally choose the wrong drug, dose, or form for administration; improved unit dose availability from the pharmaceutical companies; final preparation of drug admixtures such as antibiotics in the pharmacy, thereby eliminating drug errors and compatibility problems with the admixture solution; availability of online drug references; delivery of only one dose at a time; and delivery of single-dose packages.

BOX 6–4 Using Information Systems to Reduce Medication Errors

Order entry, pharmacy, and BCMA systems, along with automated medication supply management systems, can be used to assist healthcare providers in reducing the occurrence of medication errors. These systems interact to provide checks and alerts throughout the medication ordering and administration process, as directed in the following examples:

* 1. A physician enters a medication order into the order entry system.
* 2. The information is automatically transmitted to the pharmacy system.
* 3. The pharmacy system integrates laboratory values and uses rules to ask the physician if he or she chooses to change or add medications based on laboratory values or dose for patient size or age.
* 4. The pharmacy system checks the patient’s history and alerts the physician to any drug interactions or allergies. The physician can change the order at this time, if indicated.
* 5. The pharmacy system issues a warning when sound-alike medications are ordered, forcing the physician and caregiver to consider which drug the patient is actually to receive.
* 6. The order creates a requisition in the pharmacy that contains a barcode indicating the correct medication, as well as a barcode identifying the patient.
* 7. A robot in the pharmacy fills the medication order by matching the medication barcode on the requisition to the barcode on the medication. The medication is transported to the nursing unit.
* 8. The nurse scans the barcode on the patient’s identification band and the barcode on the medication, administers the medication only if there is a match, and documents medications given in the barcode medication administration system. A warning will appear if insufficient time has passed since the drug was last administered.
* 9. The system prompts the nurse to enter pain scale, blood pressures, and pulses where appropriate.
* 10. The system automatically adds the nurse’s electronic signature.
* 11. The barcode medication administration system can generate the following reports:
  + • A medication due list, showing medications that need to be administered within specific time parameters, including one-time, on-call, continuous, PRN orders, and regularly scheduled medications
  + • PRN effectiveness list that prompts the nurse to record the effectiveness of PRN medications
  + • Medication administration history, which records nurse initials and times for medications given in a traditional medication administration record format
  + • Missing dose report—prints in pharmacy to alert staff when a dose needs to be reissued; done at the time the nurse was administering meds with essentially no disruption in work flow
  + • Medications not given report—lists all missed doses according to the documentation on the medication administration record
  + • Variance log—captures meds given more than 30 minutes early or late

Integration of the various clinical information systems with subsequent exchange of information decreases medication errors and improves therapeutic drug monitoring in patients with compromised renal function and those receiving drugs with narrow therapeutic ranges through the use of clinical decision support (CDS) alerts. Pharmacy systems offer many benefits that promote cost containment, improve the quality of care, and decrease medication errors. These systems can be used by a variety of healthcare professionals who perform activities related to the ordering, dispensing, and administration of medications. A hospital pharmacy may use an information system to access client data such as demographics, health history and diagnosis, medication history, client allergies, laboratory results, renal function, and potential drug interactions. Traditionally, pharmacists reviewed each client’s medication profile, laboratory values, medical history, and progress notes manually to monitor medication disbursement and effectiveness. This is a time-intensive, laborious process that is no longer feasible. Automated systems pull in laboratory results and client information from the HISs more quickly and accurately than a manual process identifying allergy and interaction problems. This integration of information allows pharmacists to recommend changes in parenteral nutrition formula based on laboratory abnormalities, verify that medication dosages are appropriate based on serum drug levels, avoid drugs that may impair renal function, and monitor laboratory values for possible drug toxicity. Pharmacy systems can also provide automatic alerts that can save lives. Automation of previously manual processes also can reduce costs. Kuiper, McCreadie, Mitchell, & Stevenson ([**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8010)) noted that the successful use of technology reduced the potential for error by automating tasks that require high levels of accuracy and repetition. An example of this may be seen with the integration of intravenous administration pumps with pharmacy systems (Breland [**2010**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7941); Sullivan [**2010**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8096)).

Another benefit offered by pharmacy systems is the tracking of medication use, costs, and billing information. Automation of these functions generally improves accuracy and is more cost-effective than manual methods. In addition, this information can be manipulated and analyzed more easily for executive decision making when it is available as a computer file.

Physicians and other direct care providers may also use pharmacy systems. These systems provide online access to client and drug information that is critical in the drug prescription process. Pharmacy systems can provide easy access to clients’ health and medication history, as well as their allergies and demographic information. Access to formulary information and online drug reference information helps physicians determine the most effective drug and the appropriate doses for clients. In addition, these systems can provide comparisons of costs and drug effectiveness, particularly important in the managed care arena. Pharmacy information systems provide data for barcode medication administration (BCMA) systems.

Creating a culture of safety is a critical first step to making changes needed to reduce medication errors. There are many opportunities to use technology to prevent medication errors but the implementation of some of these applications has been delayed (Schneider [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8072)). The Institutes of Medicine recommends the use of pharmacy systems, BCMA, smart infusion pumps, and decision support software to improve safety (IOM [**1999**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8001), [**2001**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8004), [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8007)).

Pharmacy Dispensing Systems

Pharmacy systems can automatically dispense each client’s medications in unit dose format, creating labels for each dose with the client’s name and other demographic identifiers. The actual dispensing of the medications may be accomplished either with or without the intervention of the pharmacist. Some systems automatically dispense ordered medications in unit dose packages, which the pharmacy staff place in the client’s medication drawer. This process can be streamlined by using robotic systems, which collect the appropriate medications and place them in the drawers. Robotic dispensing systems are seen as a mechanism to prevent medication errors as well as reduce inventory and labor costs (Lin, Huang, Punches, & Chen [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8016)). These systems serve to support rather than supplant the pharmacist.

***Unit-Based Dispensing Cabinets***

Another aspect of pharmacy systems is the use of automatic dispensing systems for use by the nurse. These systems provide a medication dispensing unit in the clinical area, generally for use by nurses who administer medications. The system is usually secured by requiring a user ID and password or biometric measure for access to the system and the actual medications. Features include menu-driven prompts for identifying the client, medication, dose, and number of unit doses removed. The user can also be prompted to count the current number of doses on hand when removing narcotics or other controlled substances. Automatic dispensing systems provide accurate records of medicines given in terms of what was taken from the unit and the date, time, and user who performed this activity. These records can be accessed centrally in the pharmacy to determine when supplies in the clinical area dispensing units must be replenished. In addition, this information can be used to efficiently and accurately bill clients for medications used. Nurses must recognize that there are limitations to these safety devices and still carefully check medications before removing them from the cabinet, avoid returning unused doses, take only one dose for a single patient when it is needed, and avoid unsafe practices such as overriding the system (McCartney [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8037)).

***Barcode and RFID Medication Administration Applications***

Bar-Code Medication Administration is a quality initiative identified by the Leapfrog Group and the Veterans Administration’s National Center for Patient Safety (Educating patients [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7974); Schneider, Bagby, & Carlson [**2008**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8075), p. 1614). BCMA is a system that uses the barcode found on the unit-dose medication package and on a patient’s identification bracelet to ensure that nurses administer the right drug to the right patient in the right dose at the right time and by the right route (Rivish & Moneda [**2010**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8066)). It prevents errors at the point of care, where they can do the most harm. It also helps hospitals comply with the Joint Commission standards and patient safety goals. Specifically, it helps hospitals meet requirements to verify orders and patients before medication administration. The reductions in medication errors provide a return on investment (ROI) (Elganzouri, Standish, & Androwich [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7977)). BCMA systems may exist as stand-alone systems or as a part of a complete hospital information system. Typically the nurse uses a portable scanner to scan a barcode on his or her identification badge to log on to the software application. Next the patient’s identification bracelet is scanned. The system displays a list of the patient’s medication orders and times for administration. Medications due for administration are scanned as the nurse checks them. Documentation is automated with the process. Successful BCMA implementation eliminates loopholes that allow nurses to bypass key features such as scanning the patient’s identification bracelet. The extent of the benefits accrued from BCMA will be influenced by several factors, including adherence to standardized dispensing practices and human factors such as ergonomics associated with the medication cards (Mills, Neily, Mims, Burkhardt, & Bagian [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8040)). When discussing the prevention of medication errors, Manno ([**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8025), p. 60) noted that technology that is used to enhance health and delivery systems “should be designed to make it easy to do the right thing and hard to do the wrong thing.” Pairing BCMA with CPOE further decreases errors (Comeaux, Smith, & Stem [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7958)). Adding CDS to the combination drastically lowers mortality and the harm rate associated with adverse drug reactions and errors (Reifsteck, Swanson, & Dallas [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8063)). Additional features, such as prompts when pain assessments are past due, improve documentation. Other BCMA benefits include more consistent patient identification, fewer missed medication doses, and fewer adverse effects since system alerts warn the nurse of allergies and possible drug interactions (Mills et al. [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8040)). Radio Frequency Identification (RFID) technology offers the same benefits. It is slightly more expensive but is not subject to read errors with smudges or obscured visibility. The disadvantages associated with BCMA include poorly functioning scanners, identification bracelets that do not read consistently, and the need to transport equipment (McCartney [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8037)). Smart IV pumps that contain special drug error reduction software can be integrated with BCMA.

***E-Prescribing***

E-prescribing is a process that allows the physician to enter a prescription into an information system. This information is electronically communicated to the client’s pharmacy. This may be done using a variety of devices, including personal digital assistants (PDAs), wireless computers, or other handheld devices that allow prescriptions to be easily sent from the physician’s exam room or the patient’s bedside. Electronic prescriptions provide the following benefits:

* • Elimination of telephone authorization for refills
* • Review of clients’ drug histories before ordering drugs
* • Reminders to order home medications for the hospitalized client
* • Alerts about drug interactions
* • Checking of formulary compliance and reimbursement
* • Provision of a longitudinal prescription record

Electronic prescriptions require direct links between physician offices, hospitals, pharmacies, and third-party payers. E-prescribing functionality is required for Meaningful Use reimbursement for physicians so adoption rates are expected to increase exponentially (Conn [**2011**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7964)).

Physician Practice Management Systems

A survey (Mattocks et al. [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8031)) revealed that practice management systems comprised the most commonly used type of technology in physician offices. Features typically include the ability to capture some demographic information, schedule appointments, maintain lists of insurance payers, perform billing tasks, track outcomes, and generate reports. There may, or may not, be a connection to electronic patient records although this will no doubt change as more practices adopt electronic health records (EHR) systems to qualify for Meaningful Use monies. Patient records in paper format are expensive to maintain and unwieldy to handle, making it difficult to locate information quickly which contributes to the overall fragmentation of individual health records. Some physician offices accepted hardware and software supplied by local hospitals in order to use their information systems and reap the associated benefits of a unified record. Automation of physician office records helps to maintain client confidentiality and HIPAA compliance because health information is contained within the information system rather than loose papers that can easily be viewed by unauthorized clinical and nonclinical office staff.

Long-Term Health Information Systems

The adoption of information technology (IT) has been slow in long-term care for many reasons, including fragmentation among facilities, limited operating budgets, high implementation costs, and multiple providers in one facility. This situation is beginning to change (“Information technology: Is Long-Term Care Leading the Way?” [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7997)). The integration of clinical information systems in this area is imperative for the improvement of quality of care, better management of the complex needs of the population, and a decrease in adverse drug effects (Alexander, Rantz, Flesner, Diekemper, & Siem [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7920); Brandeis, Hogan, Murphy, & Murray [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7935); Gillespie [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7980); Shugarman, Nishita, & Wilber [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8081); Subramanian et al. [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8093)). The adoption of information systems is also critical to the business survival of long-term health facilities given the constantly changing financial and reimbursement system (Nahm, Mills, & Feege [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8047)). Integration must extend beyond the walls of a single long-term care facility to best serve the needs of the patients. Boston Medical Center and University Geriatric Services partnered with nursing homes in several areas to provide the hardware and software that subsequently improved communication between providers, hospital, and nursing home staff. This was particularly important given the fact that many nursing home patients have multiple transfers from one facility and set of providers to another. Long-term care information systems include documentation and financial information. Ideally, features include order entry, results retrieval, and medication administration. One particular example of improved communication is the use of the electronic record to document patient preferences about advanced directives. Lindner, Davoren, Vollmer, Williams, & Landefeld ([**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8019)) noted that modification of admission orders at a Veterans Affairs nursing home improved the completion of resuscitation status by physicians. IT also promises to ease the heavy burden of paper-based documentation in this setting. While doubts have been voiced about the acceptance of computerized documentation in long-term care, Yu, Qiu, and Crookes ([**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8109)) found that the majority of workers surveyed in nursing homes were willing to adopt electronic documentation. The cost of widespread adoption of IT in long-term healthcare must be carefully considered. The reality is that costs must be borne by facilities and physicians. Financial incentives may be required to encourage and expedite the use of technology in this arena (Subramanian et al. [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8093)).

Ambulatory Care Information Systems

Integration of technology into ambulatory care settings has been sporadic with some clinic settings having access to order entry and results retrieval from the affiliated hospital systems but still using paper for documentation. Medicare and Medicaid incentive payments are now in place for the adoption of certified EHR systems and demonstration of Meaningful Use (Collins, Wise, & HIMSS [**2010**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7954)). The Meaningful Use incentive arose from the expectation that EHRs would serve as the key to improve quality and efficiency in healthcare (HIMSS [**n.d.**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7987)).

Home Care Information Systems

Braunstein ([**1994**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7938)) noted that home care nurses were ideally situated to be early adopters of electronic systems because of their mobility, frontline role in the healthcare system, their lack of a support structure at the point of care, and the excessive demands for documentation. McBride ([**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8034)) noted that systems could be tailored to streamline the work of nurses, improve quality of care delivery, and improve payment for services because billing personnel can find needed information more quickly, allowing them to send out bills earlier. The adoption of technology for home care will increasingly make use of monitoring technology integrated into information systems as a way to care for an aging population at home (Cheek, Nikpour, & Nowlin [**2005**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7951)). At best, home care systems will communicate with hospital information systems for access to test results, medication lists and allergy information, and possibly order entry. Home care is expected to explode within the next few years given that it is more cost-effective than hospital care. A commensurate level of growth is expected in the acquisition and use of home care information systems (Homecare Information Software [**2010**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7994)).

BOX 6–5 Other Common Clinical Systems

* • Medical records/abstracting systems facilitate the abstracting, or coding, of diagnoses and chart management processes. Client records may also be stored on optical disk.
* • Operating room systems may be used to schedule procedures, manage equipment setup for individual physicians, facilitate inventory control, and provide client billing.
* • Emergency department systems provide ready access to independent systems such as poison control. They also provide tracking capability, alerts, and the capability to print specific discharge and follow-up instructions based on the client’s diagnosis.

Other Clinical Systems

A number of other clinical systems address the needs of specific departments within the healthcare setting. [**Box 6–5**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7618) lists some of these systems. The rapidly changing healthcare environment has resulted in several requirements on the part of the clinical information system vendor. The vendor’s initial support services and ability to provide ongoing support are critical success factors as the healthcare paradigm continues to shift.

Westbrook ([**2005**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8106)) summarized research that found that the successful implementation of clinical information systems was determined by the complex interaction between the technical features of the system and human, social, and organizational factors that determine whether the system will be used and whether it will prove to be safe and effective.

ADMINISTRATIVE SYSTEMS

Various administrative systems may be used in healthcare organizations to support the process of providing client care. [**Box 6–6**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7653) provides a brief review of many of these systems.

Registration Systems

The client registration system is critical to the effective operation of many other systems within the healthcare setting. This system is used to collect and store client identification and demographic data that are verified and updated at the time of each visit. For this reason, these may also be known as admission/discharge/transfer (ADT) systems. CISs use these data for the management of client care and billing purposes. The information is shared with those clinical systems that communicate directly with the registration system.

An important aspect of a registration system used in a multi-entity health system network is the development of a unique client identifier. This number or identification code is used to identify the client in all information systems across the organization and across all entities. This enables accurate client identification, supporting the development of a longitudinal client record that contains all clinical information available for the client.

Scheduling Systems

BOX 6–6 Administrative Information Systems Used in the Healthcare Setting

* • Financial systems provide the facility with accounting functions. Accurate tracking of financial data is critical for enabling the organization to receive reimbursement for services.
* • Payroll and human resource systems track employee time and attendance, credentials, performance evaluations, and payroll compensation information.
* • Contract management systems manage contracts with third-party payers.
* • Risk management systems track and plan prevention of unusual occurrences or incidents.
* • Quality assurance systems monitor outcomes and produce reports that are used to guide quality improvement initiatives.
* • Physician management systems support patient registration, scheduling, coding, and billing in the physician’s office and may support results retrieval. These systems also provide better protection of patient privacy than paper records.
* • Executive information systems provide administrators with easy access to summarized information related to the financial and clinical operations of the organization.
* • Materials management systems facilitate inventory control and charging of supplies.

A scheduling system allows a healthcare organization to schedule clients and resources efficiently. Client demographic information must be available in the system either by direct entry or through electronic communication with a registration system. For the system to be used to schedule patient appointments, it must contain information regarding available resources. This resource information may include the following:

* • Referral and authorization by patients’ insurance
* • Department
* • Equipment
* • Dates and times
* • Room
* • Staff
* • Permits and preps
* • Charging and billing information

The system uses predetermined rules for determining how resource and client information should be used to schedule a particular type of appointment. This provides the capability to schedule a patient in one location. In addition, scheduling across all facilities in an enterprise can be accomplished using one system. The benefits associated with using a scheduling system include increased staff productivity, increased client satisfaction, and cost savings to the organization.

Contract Management Systems

Contract management (CM) software provides invaluable assistance to organizations to better manage their resources and improve efficiency. Healthcare institutions typically have multiple contracts with third-party payers as well as with vendors and various suppliers. CM software provides the visibility and control that allow organizations to negotiate better contracts, ensure that suppliers meet their contractual obligations, track compliance, save money, and accelerate the cycle times from sourcing through contract (Avery 2006). Anthes ([**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7923)) noted that, traditionally, organizations focus efforts to maximize profits on cutting costs and boosting sales. Pricing is based upon competitors’ prices and production costs, plus a standard markup fee or value pricing, which segments buyers and sets prices based on each segment. Value pricing requires good use of data mining and modeling capabilities. Value pricing reflects different levels of charges set by sellers of services for patients in accordance with their insurance plan. CM software features support contract creation, report capability, e-procurement, alerts, and notifications on key business events, and can even support automation of the entire contract process.

Financial Systems

Financial systems were generally the first information systems found in healthcare delivery organizations. Integration with registration systems ensured that patient demographic data and insurance information could be accessed to charge for services provided and receive reimbursement. As the sophistication of technology increased, it became possible to charge patients automatically once a clinical service was completed. For this reason all other information systems were typically built around financial systems.

Risk Management Systems

This type of system enhances an organization’s ability to identify potential risks and develop strategies to deal with them inclusive of the ability to cross reference and compare losses using different variables and examine the impact at different levels of detail (Pozzi [**2009**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8060)). Losses can be tracked back to the point of origin to pinpoint and address specific liabilities. Both small and large organizations can benefit from risk management systems. Increasingly features include dashboard views; regular e-mailing of reports; and the ability to manage policies, claims, litigation, and other insurable risk information.

Decision Support and Expert Systems

Decision support and expert systems use data from both the clinical and the administrative information systems, and can provide information related to clinical and administrative users. According to Turley ([**1993**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8099)), little agreement exists on the definition of the terms *decision support systems* and *expert systems*except for the distinction of how much authority is placed in the computer system.

Decision support systems aid in and strengthen the selection of viable options using the information of an organization or a field to facilitate decision making and overall efficiency. Decision support software organizes information to fit new environments. It provides analysis and advice to support a choice. The final decision rests with the practitioner. Software can be off-the-shelf or homegrown. Off-the-shelf software is commercially available. The advantage to the consumer is that someone else has borne the cost for its development and testing. It is, however, geared to a general market and may not meet the needs of a particular party. Homegrown software has been developed by the consumer to meet specific needs usually because no suitable commercial package is available. The customer bears the cost of its development, testing, and communication with other software applications. Decision support software can provide a competitive edge and facilitate the move to managed care.

Clinical decision support provides clinicians with knowledge or specific information that is intelligently filtered, or presented at appropriate times, to enhance health and healthcare (Mangalampalli, Chakravarthy, Raja, Jain, & Parinam [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8022); Osheroff et al. [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8054)). Tools may include clinical practice guidelines, alerts and reminders, order sets, patient data reports and dashboards, diagnostic support, workflow tools, and financial applications. CDS is effective in all phases of the clinical process. CPOE with CDS has been shown to decrease medication errors by as much as 80% (Cornish et al. [**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid7968)). An example of a decision support application is a program that assists nurses performing a skin assessment to review available alternatives, from which the best may be selected to maintain skin integrity. CDS is best used when available at the point of care. Access is facilitated through the use of wireless devices such as PDAs, tablet computers, and iPhones, which are easily transported and with the practitioner at the point of care. While CDS has been proven effective in improving outcomes at many sites, it is not universally available or available at the same level at all locations (Simon, Rundall, & Shortell [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8084)). Strong external drivers are expected to change this situation. The American Medical Informatics Association has presented a roadmap for national action that calls for improved CDS capabilities and increased use throughout the U.S. health sector. Financial rewards for improved outcomes are expected to accelerate adoption of order entry with CDS.

Expert systems use artificial intelligence to model a decision that experts in the field would make. Unlike decision support systems that provide several options from which the user may choose, expert systems convey the concept that the computer has made the best decision based on criteria that experts would use.

KNOWLEDGE REPRESENTATION (DASHBOARD DISPLAY)

Information is often distributed across several different information systems, making it difficult to piece all of the relevant information together to see important trends or make appropriate decisions. The concept of a dashboard display is intended to address this situation bringing together important information from various systems on one screen. The significance of this capability is even greater when this display reflects real-time data. Dashboard displays may bring together key performance indicators for business decisions (Schrage [**2007**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8078)) or clinical data from several systems into a clinical dashboard. It is imperative that the persons using the dashboard have input into the identification of the indicators used and design of the actual display. There are a number of conceivable dashboard applications in clinical areas that include workload management, syndromic surveillance for trends, and individual clinical data.

BOX 6–7 Smart Technology

**Carol Curio Scholle, Marcia McCaw, Toni Morrison, Darlene Lovasik**

**The Problem**

On the cusp of healthcare reform the quest to improve quality, safety, and efficiency in patient care delivery is generating the opportunities for the creative use of technology. Healthcare reform is challenging organizations to increase quality standards while holding costs down. Regulatory organizations are not only asking for outcomes measurements but for proof of specific actions taken to achieve quality outcomes. Examples include documentation that every eligible patient receives flu and pneumonia vaccines, indwelling urinary catheters are removed at the earliest time, and all patients undergoing surgery receive their antibiotic within 60 minutes of incision. Nosocomial events such as pressure ulcers, injury from falling, and infections are no longer reimbursed by insurance payers thereby having a direct negative effect on organizational profitability. Accurate documentation by clinical staff is more important than ever not only to maintain patient safety but to meet organizational goals.

In response to these increasingly rigorous expectations, medical device and information technology companies have developed “smart” features in their products in an effort to provide safer, and more effective care options. A clinician of today may be responsible for operating and retrieving information from multiple devices which all offer essential clinical information but require him or her to manage and move this information to the right place. Such information might need to be documented in the electronic medical record (EMR), referenced and acted upon, or communicated to another provider. In any event manipulation of information requires additional time, attention, and actions by the clinician. The goal of Smart technology is to eliminate these extra steps.

**What Is “Smart” Technology?**

Smart technology is a system that optimizes workflow efficiency by solving real problems and ties multiple electronic solutions together to create seamless workflow for the clinician at the point of care. Smart technology enhances quality by reducing opportunity for error, prioritizing and reminding caregivers of tasks that need to be completed, and allows real-time documentation of tasks at the point of care. Real-time documentation also reduces steps for staff by eliminating the need for movement from the patient room to a computer. This documentation model also eliminates the opportunity for transcription error when clinicians enter information into the EMR which may be noted on a piece of paper at the point of care.

**Benefits for Clinicians**

This real-time documentation and point of care information display creates transparent communication between clinicians. For example, vital signs that are done and documented in the room by the nursing assistant are immediately available to the nurse who may be able to save steps by going to the medication room to get the antihypertensive medication to treat the elevated blood pressure prior to entering the patient room thereby saving time and steps. It also minimizes interruptions in care delivery, which have been proven to be opportunities for errors, particularly errors of omission, to occur. Ultimately, clinical staff are able to work in a more efficient manner. Reduced costs related to unanticipated overtime from rework, repeating steps, and batch documentation may be realized. Errors of omission, such as not consistently providing every two-hour change in position for an immobile patient, may result in pressure ulcers. In our current environment, in addition to the pain, suffering, and potential long-term adverse outcome to which the patient may be exposed, treatment related to this type of nosocomial event would not be reimbursed by payers. Smart technology puts reminders for this type of routine care at the point of care, making it difficult to omit by analyzing patient information and using clinical intelligence to determine priorities. Telemedicine systems may also be interfaced through smart technology. Physicians who practice from multiple locations have the opportunity to examine and interview their patients via a high-resolution video even when off-site. This feature supports continuity in care and allows the treatment plan to progress without interruption or delay.

**Benefits for Patients and Families**

Patients and families may also reap the benefits of smart technology. Systems may allow the patient to make nonurgent requests such as requesting a blanket, water, toiletries, or nutrition electronically and send the request directly to the person who can deliver the service. So instead of the patient calling out to the unit secretary via a call light system to request a fresh water pitcher and the secretary calling the nursing assistant to fulfill the request, the request can be sent directly to the nursing assistant, reducing response time and improving patient satisfaction and comfort.

The technology can also be used for education of patient and family-related education related to conditions and procedures. Documentation of the education can be interfaced with the EMR. The education can be designed interactively with learning customized for a particular patient’s needs, the ability to answer questions regarding understanding of materials presented, and the ability to document questions that the patient might want to ask of the caregiver for clarification.

The daily plan of care can be displayed for patients so that they know what to anticipate for the day. Goals for discharge can be made available to keep the patient, family, and entire care team on track with the plan.

The system may also include distractions for patients such as relaxation videos, electronic games, and e-mail availability. Patients who are in the hospital for a particularly long stay appreciate the ability to receive pictures and messages from their family and friends electronically and have pictures displayed in a slide show fashion if they desire.

**Current State of “Smart Technology”**

Currently there are a very limited number of systems that offer the benefits of smart technology. UPMC, a hospital system in Pittsburgh, Pennsylvania, developed a “smart” system following the identification of staff need to have information available at the point of care. UPMC is currently working in partnership with IBM to commercialize the SmartRoom workflow optimization system. Using real-time location system (RTLS) technology the system then authenticates the staff member and calls up real-time information and tasks from key clinical systems, such as the pharmacy and laboratory, on the display screen based on role. The underlying workflow module of the SmartRoom prioritizes tasks based on algorithms derived from optimal nursing workflow model. The clinician then calls up the task on the display screen and documents completion via touch screen with automatic updating of the appropriate portion of the patient’s electronic medical record. The information is immediately available in the EMR for view by all care providers. The system may also pull up clinical information for reference during routine physician and nursing rounds and for patient teaching and plan of care discussions with the patient and family. The initial design and ongoing development and customization of the product include active and ongoing input and feedback from the end users, the clinicians at the bedside.

In the test environment the system demonstrated an 82% reduction in the time associated with documentation of vital signs, 57% reduction time associated with documentation of tasks, and 69% reduction in time associated with the documentation of activities of daily living (ADL). The SmartRoom system weighs tasks based on the relevance to patient safety; so a request for a blanket is prioritized lower than need for postprocedure vital signs, directing the staff to the place of the most urgent need. Tasks that, if omitted or delayed, could cause harm or a risk to patient safety are pushed to the top of the clinician’s “to do” list. This prioritization helps to reduce missed care.

**Opportunities for Future Development**

Throughout the development and implementation of SmartRoom at UPMC, input on additional features that might be added to improve the patient experience and clinician workflow included:

* • Full interface with the physical assessment documentation in the EMR
* • Point-of-care lab label printing
* • Physician order entry
* • Telemedicine ability
* • Direct integration with devices that have smart features such as:
  + • Smart pumps
  + • Vital sign monitors
  + • Electronically controlled beds
  + • Smart phones
  + • Barcode scanning devices for:
    - • Medications
    - • Glucose meters
    - • Blood products

The list of enhancements that have been requested and are being explored to enhance the patient experience includes:

* • Ability to view and review tests and procedures with the care team
* • Electronic “just in time” dietary menu options
* • Ability to order personal items from the hospital gift shop
* • Survey of patient experience

**Obstacles**

As with development, implementation, and adoption of any new technology, obstacles appear along the way. Much of the technology that is currently in operation in today’s hospitals is operating off the platform HL7, which has been in existence since the 1980s. Because of the age of this operating system, its capabilities are limited, if not challenging, to adapt into our current environment. Clinicians who use laptops, smart phones, and computers that work at lightning speed do not easily tolerate cumbersome systems that may still exist in the hospital environment. Systems often do not have the inherent ability to “talk” to each other. Smart technology needs to be able to crack the code, so to speak, to allow for translation of information from system to system thereby integrating the systems. This can be a significant challenge to overcome, depending on the systems.

As technology has evolved, many large or even not so large healthcare facilities have many, many different electronic systems. Some may even have more than one system to accomplish the same function in the same building. These systems not only need to be able to listen and understand all of the data coming in and have the ability to push data out, but need to be able to process and display the information in a format that is retrievable and usable for the front-line staff. These systems include those used for:

* • Laboratory processing and reporting
* • Pharmacy services
* • Clinical documentation
* • Data reporting
* • Patient imaging
* • Supply chain management
* • Nutrition systems

**Expense**

There are capital expenses related to installation and implementation of this new type of technology which may not have easily quantifiable value to those who may be responsible for allocating funds to support this type of system. Smart technology is a tool to integrate existing technologies and it is not in and of itself a technology that will necessarily provide new or essential function. Demonstrating the value of the system requires looking carefully at roles, workflow, time studies of work, and costs associated with errors in transcription of information or errors of omission. In short it requires building a case for making the investment and demonstration of ROI. As with all technology, in addition to initial hardware, software, and infrastructure costs, system support and maintenance needs must be factored into the equation.

**Adaption to Adoption**

Adaption is when a form or structure is modified to fit a changed environment.

Adoption is to take over an idea or practice as if it were one’s own.

Initial adaptation to new technology, despite the ultimate enhancement to workflow or work quality, is always a challenge since it requires people to change their routine and behaviors. Education and support during the implementation is a key element associated with success. This support will allow staff to adapt to the new tool. Adoption is quite another matter. Adoption happens when the new tool or technology becomes part of the new workflow and routine. Adoption is hardwired when staff find it difficult to work without the new tool.

Adoption happens at different rates for different people. Background, exposure, experience, and generation have a significant impact on how willingly or quickly people adopt new ideas, practices, or workflow. A key element of a successful piece of smart technology is it is simple and intuitive to use for all. Baby-Boomers and generation Xers should be able to easily learn how, or just instinctively know how, to use the technology. Reducing steps and the time that it takes to do the work is an invaluable feature for any technology. If the technology is also simple to use, requires little education or reinforcement for people to remain competent in use of the system, adoption is facilitated and the change may become hardwired into workflow.

FUTURE DIRECTIONS

Information technology applications will become more commonplace, be easier to use, and offer additional features from this point forward. The drivers for this trend will include concerns for safety, worker retention, the need to expand evidence for evidence-based practice, reimbursement, and cost containment. McCartney ([**2006**](https://jigsaw.vitalsource.com/books/9781323102497/epub/OPS/loc_016.xhtml#eid8037)) noted that technology “can promote a safe environment for nursing practice by reducing negative exposure to risk and liability.” Electronic databases offer the potential to facilitate retrospective analysis of errors.

CASE STUDY EXERCISE

You are a nurse participating in the customization and implementation of a barcode medication administration system. Analyze how the process will change from the current manual process. Include potential problem areas and solutions.

SUMMARY

 Visit [**nursing.pearsonhighered.com**](http://nursing.pearsonhighered.com/) for additional cases, information, and weblinks.

* • A hospital or healthcare information system consists of clinical and administrative systems.
* • Well-designed clinical information systems can improve the quality of client care.
* • Clinical information systems can extend the capabilities of healthcare providers.
* • A nursing information system using the nursing process approach should support the use and documentation of nursing processes and provide tools for managing the delivery of nursing care.
* • The use of standardized nursing languages such as NANDA, NIC, and NOC supports automation of nursing documentation and expands the utility of collected information.
* • The critical pathway/protocol approach to nursing information systems provides a multi-disciplinary format for planning and documenting client care.
* • Other clinical systems, including order entry, radiology, laboratory, pharmacy systems, and physician management systems, give the nurse and other healthcare providers the support and tools to more effectively care for clients.
* • Administrative systems support the process of client care by managing nonclinical, client-related information, including demographics, codes for procedures, and insurance.
* • Information systems enable decision makers to examine trends and make informed choices during these times of healthcare reform.
* • Federal initiatives for patient safety call for the implementation of computerized physician order entry and barcode medication administration as methods to reduce error.
* • Personal device assistants and wireless technology further enhance the capability of information systems to support the work of clinicians.

REFERENCES

Alexander, G. L., Rantz, M., Flesner, M., Diekemper, M., & Siem, C. (2007). Clinical information systems in nursing homes: An evaluation of initial implementation strategies. *Computers Informatics Nursing, 25*(4), 189–197.

Anthes, G. (2006). The price point. *Computerworld, 40*(30), 33–35.

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

Avery, S. (2005). How to use software to manage contracts. *Purchasing, Electronics & Technology, 134*(11), 39–41.

Bradley, V. B., Steltenkamp, C. L., & Hite, K. B. (2006). Evaluation of reported medication errors before and after implementation of computerized practitioner order entry. *Journal of Healthcare Information Management, 20*(4), 46–53.

Brandeis, G. H., Hogan, M., Murphy, M., & Murray, S. (2007). Electronic health record implementation in community nursing homes. *Journal of the American Medical Directors Association, 8*(1), 31–34.

Braunstein, M. L. (1994). Electronic patient records for homecare nursing. *Computers in Nursing, 12*(5), 232–238.

Breland, B. D. (2010). Practice report. Continuous quality improvement using intelligent infusion pump data analysis. *American Journal of Health-System Pharmacy, 67*(17), 1446–1455.

Centers for Medicare & Medicaid Services (CMS). (2010, July 28). Electronic health record incentive program final rule. *Federal Register, 75*(144), 44313–44588. Retrieved November 13, 2011, from [**http://edocket.access.gpo.gov/2010/pdf/2010-17207.pdf**](http://edocket.access.gpo.gov/2010/pdf/2010-17207.pdf)

Chazard, E., Ficheur, G., Merlin, B., Serrot, E., Beuscart, R., et al. (2009). Detection and prevention of adverse drug events: Information technologies and human factors. Adverse drug events prevention rules: Multi-site evaluation of rules from various sources. *Studies in Health Technology & Informatics, 148*, 102–111.

Cheek, P., Nikpour, L., & Nowlin, H. D. (2005). Aging well with smart technology. *Nursing Administration Quarterly, 29*(4), 329–338.

Collins, D. A., Wise, P. B., & Healthcare Information and Management Systems Society (HIMSS). (2010, December). *Meaningful use: Lessons learned on the path to EHR excellence in ambulatory care*. Retrieved November 13, 2011, from [**http://www.chcf.org/publications/2010/12/meaningful-use-lessons-learned**](http://www.chcf.org/publications/2010/12/meaningful-use-lessons-learned)

Comeaux, K., Smith, M. E., & Stem, L. G. (2006). Tech update. Improve PRN effectiveness documentation. *Nursing Management, 37*(9), 58.

Conn, J. (2007). More moving to entry level. CPOE adoption slowly gains ground, with larger number expecting installations. *Modern Healthcare, 37*(9), 41.

Conn, J. (2011, May 5). Study outlines docs’ eRx barriers. *Modern Healthcare*. Retrieved November 13, 2011, from [**http://www.modernhealthcare.com/article/20110505/NEWS/305059989/&template=printpicart**](http://www.modernhealthcare.com/article/20110505/NEWS/305059989/&template=printpicart)

Cornish, P. E., Etchells, E. E., & Knowles, S. R. (2006). Pharmacists’ role in assessing potential value of CPOE. *American Journal of Health-System Pharmacy, 63*(22), 2182–2184.

Dentzer, S. (2009). Health information technology: On the fast track at last? *Health Affairs, 28*(2), 320–321.

Educating patients. (2007). *Hospitals & Health Networks, 81*(9), 82.

Elganzouri, E., Standish, C., & Androwich, I. (2009). The mat study: Global insight into the medication administration process. *Studies in Health Technology and Informatics, 146*, 424–428. doi:10.3233/978-1-60750-024-7-424

Gillespie, G. (2007, April). Erickson health takes long view with technology. *Health Data Management*. Retrieved November 29, 2007, from Erickson Health Takes Long View with Technology: [**http://www.mywire.com/pubs/HealthDataManagement/2007/04/01/3178636?extID=10037&oliID=229**](http://www.mywire.com/pubs/HealthDataManagement/2007/04/01/3178636?extID=10037&oliID=229)

Goedert, J. (2007). A new battery of tests for lab systems. *Health Data Management, 15*(9), 40–46.

Healthcare Information Management and Systems Society (HIMSS). (n.d.). *Meaningful use for ambulatory practices*. Retrieved November 13, 2011, from [**http://www.himss.org/asp/topics\_FocusDynamic.asp?faid=408**](http://www.himss.org/asp/topics_FocusDynamic.asp?faid=408)

Hendrickson, M. (1993). The nurse engineer: A way to better nursing information systems. *Computers in Nursing, 11*(2), 67–71.

Homecare information software and services market shares, strategies, and forecasts, worldwide, 2010 to 2016. (2010, February 09). *M2pressWIRE*.

Information technology: Is long-term care leading the way? (2009). *Long-Term Living: For the Continuing Care Professional, 58*(6), 53–54. Retrieved November 13, 2011, from [**http://www.ltlmagazine.com/ME2/dirmod.asp?sid=9B6FFC446FF7486981EA3C0C3CCE4943&nm=All+Issues&type=Publishing&mod=Publications%3A%3AArticle&mid=8F3A7027421841978F18BE895F87F791&tier=4&id=38CB8893F2D54E5E9995BC16E0F4A644**](http://www.ltlmagazine.com/ME2/dirmod.asp?sid=9B6FFC446FF7486981EA3C0C3CCE4943&nm=All+Issues&type=Publishing&mod=Publications%3A%3AArticle&mid=8F3A7027421841978F18BE895F87F791&tier=4&id=38CB8893F2D54E5E9995BC16E0F4A644)

Institute of Medicine (IOM). (1999). *To err is human: Building a safer health system*. Washington, DC: National Academies Press.

Institute of Medicine (IOM). (2001). *Crossing the quality chasm: A new health system for the 21st century*. Washington, DC: National Academies Press.

Institute of Medicine (IOM). (2007). *Preventing medication errors: Quality chasm series*. Washington, DC: National Academies Press.

Kuiper, S., McCreadie, S., Mitchell, J., & Stevenson, J. (2007, January 5). Medication errors in inpatient pharmacy operations and technologies for improvement. *American Journal of Health-System Pharmacy, 64*(9), 955–959. Retrieved November 19, 2007, from CINAHL.

Leapfrog hospital survey results 2008. (2009). *Medical Benefits, 26*(12), 4.

Lin, A. C., Huang, Y. C., Punches, G., & Chen, Y. (2007). Effect of a robotic prescription-filling system on pharmacy staff activities and prescription-filling time. *American Journal of Health-System Pharmacy: Official Journal of the American Society of Health-System Pharmacists, 64*(17), 1832–1839.

Lindner, S. A., Davoren, J. B., Vollmer, A., Williams, B., & Landefeld, C. S. (2007). An electronic medical record intervention increased nursing home advance directive orders and documentation. *Journal of the American Geriatrics Society, 55*(7), 1001–1006.

Mangalampalli, A., Chakravarthy, R., Raja, M., Jain, A., & Parinam, A. (2006). IT systems. Clinical systems: Using IT to improve care. *British Journal of Healthcare Management, 12*(9), 277–281. Retrieved November 19, 2007, from CINAHL with Full Text database.

Manno, M. (2006, March). Preventing adverse drug events. *Nursing, 36*(3), 56–62. Retrieved November 19, 2007, from CINAHL with Full Text database.

Matsuura, G. T., & Weeks, D. L. (2009). Use of pharmacy informatics resources by clinical pharmacy services in acute care hospitals. *American Journal of Health-System Pharmacy, 66*(21), 1934–1938.

Mattocks, K., Lalime, K., Tate, J. P., Giannotti, T. E., Carr, K., Carrabba, A.,… Meehan, T. P. (2007). The state of physician office-based health information technology in Connecticut: Current use, barriers and future plans. *Connecticut Medicine, 71*(1), 27–31.

McBride, M. (2006). The home healthcare pot of gold. *Health Management Technology, 27*(5), 22–23.

McCartney, P. (2006). Using technology to promote perinatal patient safety. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 35*(3), 424–431.

Mills, P. D., Neily, J., Mims, E., Burkhardt, M. E., & Bagian, J. (2006). Improving the bar-coded medication administration system at the Department of Veterans Affairs. *American Journal of Health-System, 63*(15), 1442–1447.

Moniz, B. (2009). Examining the unintended consequences of computerized provider order entry system implementation. *Online Journal of Nursing Informatics, 13*(1), 1. Retrieved November 13, 2011, from [**http://ojni.org/13\_1/moniz.pdf**](http://ojni.org/13_1/moniz.pdf)

Nahm, E. S., Mills, M. E., & Feege, B. (2006). Long-term care information systems: An overview of the selection process. *Journal of Gerontological Nursing, 32*(6), 32–38.

The National Coordinating Council for Medication Error Reporting and Prevention. (2005, December). *NCC MERP: The first ten years “defining the problem and developing solutions.”* Retrieved from [**http://www.nccmerp.org/pdf/reportFinal2005-11-29.pdf**](http://www.nccmerp.org/pdf/reportFinal2005-11-29.pdf)

Osheroff, J. A., Teich, J. M., Middleton, B., Steen, E. B., Wright, A., & Detmer, D. E. (2007). A roadmap for national action on clinical decision support. *Journal of the American Medical Informatics Association, 14*(2), 141–145.

Powell, V. (2011). Finding the pulse of health technology. *Pharmaceutical Representative, 41*(2), 24–25.

Pozzi, S. R. (2009). Monitor, measure and manage ERM. *Best’s Review, 110*(2), 84.

Reifsteck, M., Swanson, T., & Dallas, M. (2006). Driving out errors through tight integration between software and automation. *Journal of Healthcare Information Management, 20*(4), 35–39.

Rivish, V. O., & Moneda, M. D. (2010). Medication administration pre and post BCMA at the VA medical center. *Online Journal of Nursing Informatics, 14*(1), 1–21.

Rogoski, R. (2003). LIS and the enterprise. *Health Management Technology, 24*(2), 20–23.

Schneider, P. J. (2007). Opportunities for pharmacy. *American Journal of Health-System Pharmacy, 64*(14), S10–S16.

Schneider, R., Bagby, J., & Carlson, R. (2008). Bar-code medication administration: A systems perspective. *American Journal of Health-System Pharmacy, 65*(23), 2216–2219.

Schrage, M. (2007). *Business Finance, 13*(4), 64.

Shugarman, L. R., Nishita, C. M., & Wilber, K. H. (2006). Building integrated information systems for chronic care: The California experience. *Home Health Care Services Quarterly, 25*(3–4), 185–200.

Simon, J. S., Rundall, T. G., & Shortell, S. (2007). Adoption of order entry with decision support for chronic care by physician organizations. *Journal of the American Medical Informatics Association, 14*(4), 432–430.

Smetzer, J., & Navarra, M. B. (2007). Patient safety. Measuring change: A key component of building a culture of safety. *Nursing Economics, 25*(1), 49–51.

Standardize order sets for improved care. (2010). *Health Management Technology, 31*(2), 38–39.

Subramanian, S., Hoover, S., Gilman, B., Field, T., Mutter, R., & Gurwitz, J. (2007, September). Computerized physician order entry with clinical decision support in long-term care facilities: Costs and benefits to stakeholders. *Journal of the American Geriatrics Society, 55*(9), 1451–1457. Retrieved November 19, 2007, from Health Source: Nursing/Academic Edition database.

Sullivan, M. (2010). Improving patient safety with intelligent infusion devices. *American Journal of Health-System Pharmacy, 67*(17), 1415. doi:10.2146/ajhp100316

Turley, J. P. (1993, May). *The use of artificial intelligence in nursing information systems*. Retrieved from [**http://www.vicnet.net.au/vicnet/hisa/MAY93/MAY93-The.html**](http://www.vicnet.net.au/vicnet/hisa/MAY93/MAY93-The.html)

Weant, K., Cook, A., & Armistead, J. (2007, March 1). Medication-error reporting and pharmacy resident experience during implementation of computerized prescriber order entry. *American Journal of Health-System Pharmacy, 64*(5), 526–530. Retrieved November 19, 2007, from Health Source: Nursing/Academic Edition database.

Westbrook, J. (2005). Guest editorial: Exploring the interface between organisations and clinical information systems. *Health Information Management Journal, 4*, 102–103.

Yu, P., Qiu, Y., & Crookes, P. (2006). Computer-based nursing documentation in nursing homes: A feasibility study. In H. Park, P. Murray, & C. Delaney (Eds.). *Consumer-centered computer-supported care for healthy people—Proceedings of NI2006*, pp. 570–574.