

# Addressing Medication Errors in Hospitals

**A Framework for  
Developing a Plan**

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Prepared for  
California HealthCare Foundation  
by Protocare Sciences

## *Acknowledgments*

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The previously released *Primer On Physician Order Entry* is also available at <http://quality.chcf.org> or may be ordered through the Publications Line.

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## *Executive Summary*

The problem of medical errors, and in particular, medication errors, brought vividly to public attention by the 1999 Institute of Medicine (IOM) report, *To Err Is Human: Building a Safer Health System*, has prompted a strong response by the health care industry, purchasers, and by state and federal government. Medical errors are the eighth leading cause of death in the United States, with the number of deaths exceeding those associated with motor vehicle accidents, breast cancer, or AIDS. Medication errors represent the largest single cause of errors in the hospital setting, accounting for more than 7,000 deaths annually—more than the number of deaths resulting from workplace injuries.<sup>1</sup>

The IOM report made reference to information technologies that have been shown to be effective in reducing medical errors, particularly in hospital settings. Also, the Agency for Healthcare Research and Quality recently reported that hospitals can save as much as \$500,000 a year by using computerized medication systems.<sup>2</sup> In addition to the intense interest of the health care system in reducing the human and financial cost of medication errors, the issue has prompted a strong response from purchasers, regulators, and state and federal governments. Prominent examples include initiatives by the Leapfrog Group, a consortium of large private and public companies that purchase health care benefits for more than 20 million Americans; the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), which evaluates and accredits nearly 19,000 health care organizations annually; and, closer to home, the California State Legislature. Senate Bill No. 1875 requires every general acute care hospital, special

hospital, and surgical clinic in California (with the exception of small and rural hospitals) to adopt a formal plan for minimizing medication-related errors as a condition of licensure. This plan, to be implemented on or before January 1, 2005, must include “technology implementation, such as, but not limited to, computerized physician order entry or other technology” to eliminate or substantially reduce medication-related errors.

In order to assist health care providers in this urgent quality improvement endeavor, the California HealthCare Foundation recently published *A Primer on Physician Order Entry*, which describes computerized physician order entry (CPOE) systems and provides case studies of hospitals that have implemented these systems. As a follow-up to that piece, the Foundation commissioned Protocare Sciences to prepare this practical framework or tool kit, which hospitals can use when considering how best to proceed in choosing and applying a variety of technological solutions, including CPOE, to prevent medication errors in the hospital setting.

In the context of medication use, the ideal information technology (IT) infrastructure would include modules that enable clinicians to make the most appropriate decisions about patient care at each step of the process. Ideally, a hospital would have a series of systems (e.g., CPOE, pharmacy, laboratory, medication administration) that are all interconnected and can share data fully in “real time.” These components could be part of a single integrated system or linked through a series of interfaces. A small number of hospital organizations are close to achieving this ideal, having

invested many years and significant resources in the design, development, and implementation of various technologies that support this infrastructure. However, the vast majority of hospitals face serious constraints in the form of limited funding, competing priorities, and the presence of older legacy information systems. Their favored approach is to enhance existing information systems or add technologies in a modular fashion. While that strategy may not be ideal, it is often the most realistic and viable use of available resources.

That said, a modular approach can be seen as a way to work towards an ideal IT infrastructure. At the same time that the organization hones in on a short-term strategy for applying IT modules to attack its biggest problems first (which is what the materials in this tool kit are designed to do), it is critical for hospital leaders to develop a long-term strategy for bringing together the different modules into an integrated system. By keeping this ultimate vision in mind, administrators can ensure that they follow a rational sequence of steps when seeking and adopting technologies to improve medication safety.

## **Purpose of the Tool Kit**

The objectives of this tool kit are as follows:

- Provide hospital leaders with a foundation for discussing the causes and implications of problems in their facilities by offering information on the magnitude, causes, and impact of medication errors.
- Explain how technology can contribute to reducing errors and how hospitals can apply specific modules at each step of the medication use process.

- Promote an emphasis on technological solutions as an integral part of a comprehensive strategy to improve medication safety.
- Offer a step-by-step approach to identifying and targeting the causes of medication errors with appropriate technological applications.
- Assist hospital leaders in assessing the organization's readiness to implement technologies that facilitate the medication process.
- Help hospitals select products that are consistent with the organization's goals and available resources.
- Provide a list of IT vendors serving the hospital market and examples of currently available products that focus on reducing medication errors.

The information in this tool kit is based on a review of the pertinent literature as well as interviews with representatives of hospitals, hospital systems, and IT vendors. (For more on methodology, please see Appendix A.) The framework in which these tools are presented has been designed to enable hospital leaders to hone in on the individual technological applications that will have the greatest impact on the major causes of medication errors and adverse drug events (ADEs) in their facility. However, it is crucial that hospital leaders consider each potential solution in the context of a long-term strategy for using information systems to improve patient safety. Because of the ways in which information systems must relate to each other, no decision can be made in a vacuum. Moreover, without a long-term perspective, it is almost impossible to determine the best sequence of steps for an organization, or to identify and make tradeoffs between different options.

## Summary of Recommendations

The recommendations in this tool kit are presented in the context of four steps that lead the hospital from an initial evaluation of its processes to the implementation of an appropriate technological solution. Each of these recommendations is associated with one or more tools or templates, which are presented in the accompanying binder (or can be downloaded from the California HealthCare Foundation's Web site: <http://quality.chcf.org>). Hospitals can customize these tools to meet their needs and use the tools in conjunction with other available resources to highlight specific medication safety issues. Taken together, the recommendations and tools offer a systematic and institutionally verified approach to addressing medication errors with information technologies.

### Step 1: Assess the Hospital's Readiness

- Conduct an assessment of processes, resources, and strategic goals related to medication and patient safety in order to identify and establish priorities for the most appropriate and realistic technological solutions or enhancements.

### Step 2: Prepare the Organization; Formulate a Plan

- Educate all members of the hospital community (providers, patients, and ancillary staff) on medication safety and how existing and new technologies can be used to support efforts to reduce medication errors.
- Begin formulating a plan for adopting technology in the organization by focusing on the pharmacy information system and ensuring that its clinical functionality has been optimized (e.g., clinical checks and alerts are available and activated).
- With regard to ADE reporting, emphasize a non-punitive environment, a multidisciplinary

approach, and a commitment to conduct root cause analyses and apply solutions on a system-wide basis.

### Step 3: Evaluate and Select Technological Solutions

- Conduct a detailed examination of the steps involved in preparing the organization technically for system implementation *prior* to product selection.
- Define the organization's expectations for vendor support and mandate a response to these expectations during the request for proposal (RFP) process.
- Since pharmacy information systems are widely available and implemented in many hospitals, they should be the initial focus for improvement or replacement. These systems are also the "hub" from which other technologies are enabled and added in a modular fashion, including CPOE.
- Enhance the functionality of the pharmacy information system by building a link to the laboratory system so that laboratory information is available to the pharmacist during order entry.
- Implement an order management imaging system that helps to prevent errors related to illegible orders and improve workload efficiencies in the pharmacy (as a result of fewer phone calls and interruptions, for example).
- Once pharmacy information systems are fully functional, adopt automated dispensing carts that can only be accessed upon order verification by the pharmacist (with the exception of carefully selected "emergency" drugs).
- Consider CPOE only if the organization has the financial and manpower resources available to appropriately manage the implementation process and mandate its use.

- If CPOE is implemented, link it to pharmacy information systems for order verification and nursing point-of-care systems (if available) in order to maximize the potential for reducing medication errors at each step of the medication use process.

#### **Step 4: Implement Technologies**

- Allocate adequate resources to build and customize database files, regardless of the type of system.
- Prepare for intensive training and utilization of resources during the implementation of systems that require significant involvement from physicians (particularly CPOE).
- Allow for adequate staffing support and prepare an aggressive roll-out schedule.

This document is intended to provide hospitals with a framework for using technology to address the problems associated with medication errors. However, technology alone is not a cure for the complex problem of medication errors. Comprehensive medication safety strategies should also include non-technological solutions such as dosing pocket cards and the use of standard order forms. It is important to recognize that the use of technology to reduce medication errors is just one component of an organizational strategy to create a “culture of safety” that includes leadership involvement and an environment committed to patient safety. This requires that the organization have a “voice at the top” ready and willing to set the tone for an open, non-punitive environment that supports discussion of errors and ways to prevent them.



## *How Technology Can Help Reduce Medication Errors*

While many health care practitioners have long been aware of the problem of medical errors, it is only recently—with the 1999 publication of a report by the Institute of Medicine (IOM)—that the public has come to appreciate the extent to which these errors put them at risk. The IOM's report, *To Err Is Human: Building a Safer Health System*, highlighted alarming statistics about the scope of the problem: medical errors are the eighth leading cause of death in the United States, with the number of deaths exceeding those associated with motor vehicle accidents, breast cancer, or AIDS. Medication errors represent the largest single cause of errors in the hospital setting, accounting for more than 7,000 deaths annually—more than the number of deaths resulting from workplace injuries.<sup>1</sup>

Recognizing that a multitude of factors can contribute to errors in health care settings, the IOM report argues that the cause of most errors is system failures, rather than individual lapses in conduct or behavior. Thus, the solution to medication errors is to identify, compensate for, and, when possible, eliminate weaknesses in the system. For example, a systems analysis reveals that most medication errors occur when physicians order the drugs and when nurses administer them.<sup>3</sup> Errors arising from such failures in the “drug ordering-delivery system” can be addressed with a comprehensive medication safety strategy that includes any of a number of emerging information technology solutions. Although the use of technology is not the only way to solve the problem of medication errors, it can play a major role in reducing medication errors when used appropriately and as part of a larger strategy. The primary contribution

of technology is its capacity to provide timely access to clinical information at key stages of the medication use process and to standardize or automate certain processes of care.

But the decision to adopt information technologies to reduce medication errors is not a simple one. How can hospital administrators and physicians determine which technologies are most appropriate for them? To assist hospitals in taking this major step towards preventing medication errors, the California HealthCare Foundation first published a report on computerized physician order entry (CPOE), which is widely regarded as a critical application for reducing medication errors. Recognizing that CPOE is not the right answer for everyone, and that it is only one of several technologies that hospitals may want to consider, the Foundation decided to create a tool kit as well that would help hospitals evaluate all of their options. To that end, the Foundation commissioned Protocare Sciences to lay out the steps involved in identifying needs, assessing and choosing appropriate technologies, and preparing the organization for new systems.

To support hospitals in these tasks, this tool kit provides a set of recommendations, self-assessment and evaluation tools, and vendor profiles. This information is based on a review of the pertinent literature as well as interviews with representatives of hospitals, hospital systems, and information technology (IT) vendors. (For more on methodology, please see Appendix A.) The framework in which these tools are presented has been designed to enable hospital leaders to hone in on the individual technological applications that will have

the greatest impact on the major causes of medication errors and adverse drug events in their facility. However, it is crucial that hospital leaders consider each potential solution in the context of a long-term strategy for using information systems to improve patient safety. Because of the ways in which information systems must relate to each other, no decision can be made in a vacuum. Moreover, without a long-term perspective, it is almost impossible to determine the best sequence of steps for an organization, or to identify and make tradeoffs between different options.

### Objectives of this Tool Kit

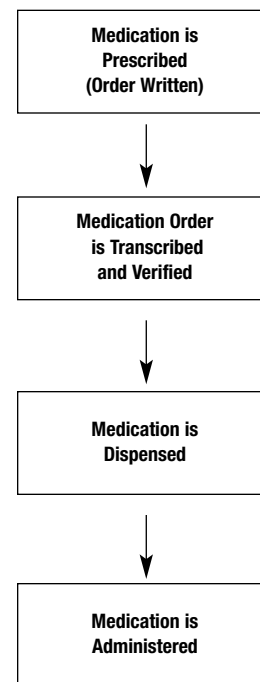
- Provide hospital leaders with a foundation for discussing the causes and implications of problems in their facilities by offering information on the magnitude, causes, and impact of medication errors at the national level.
- Explain how technology can contribute to reducing errors and how hospitals can apply specific modules at steps of the medication use process.
- Promote an emphasis on technological solutions as an integral part of a comprehensive strategy to improve medication safety.
- Offer a step-by-step approach to identifying and targeting the causes of medication errors with appropriate technological applications.
- Assist hospital leaders in assessing the organization's readiness to implement technologies that facilitate the medication process.
- Help hospitals select products that are consistent with the organization's goals and available resources.
- Provide a list of IT vendors serving the hospital market and examples of currently available products that focus on reducing medication errors.

### Where Errors Occur

In order to assess the potential and relative value of specific solutions, hospital leaders must first understand the process of medication use in the hospital setting, the points at which errors tend to occur, and the kinds of errors that can happen. This section reviews these issues in order to set the stage for a discussion of the technological applications that hospitals may want to consider.

Figure 1 illustrates the progression of a medication from the point at which it is ordered to the point where it is administered to a patient.

FIGURE 1. Medication Use Process



Medication errors encompass anything that prevents the “right patient” from receiving the “right drug” in the “right dose” at the “right time” through the “right route” of administration; they can occur at any point in the process. These errors may or may not lead to adverse drug events (ADEs), which are instances in which an injury has resulted from a medical intervention related to a drug. Likewise, not all ADEs are a result of medication errors (e.g., unknown allergic reactions). To intercept or avoid errors, all hospitals have in place systems of “checks and balances”—one example would be that all medication orders must be reviewed by a pharmacist before the dose can be dispensed for administration to the patient. However, according to a landmark study of medical errors and adverse drug events, these systems are not infallible: they intercept only 27% of potential and preventable adverse drug events.<sup>3</sup>

A large number of ADEs are preventable; these ADEs occur most frequently at the prescribing and drug administration steps of the medication use process,<sup>4</sup> which are also where the highest percentages of medication errors occur (see Table 1). Although medication errors have a similar rate of incidence at these two steps, the percentage of those intercepted, or caught before harm has been done, has been found to be highest for prescribing and lowest for administration. Administration errors are the least likely to be intercepted because this last step of the medication use process gets the

least amount of support from redundancy or “double checking.” Errors due to transcribing and dispensing are far less common, but not inconsequential. Depending on the organization, interventions that help to prevent medication errors may be valuable at all stages of the medication use process.<sup>3</sup>

### Common Types of Errors and Why They Occur

For each step in the medication use process, there are several ways in which errors may occur.

- Incorrect dosage is the most common type of error at all steps, although it occurs most often at the time of prescribing.

**Table 1.**  
**Interception of Errors During the Medication Use Process**

<b>Medication Use Step and Common Types of Errors</b>	<b>Distribution of Errors By Step</b>	<b>Percentage of ADEs Intercepted</b>
<b>Prescribing</b> ■ Wrong dose ■ Wrong choice ■ Known allergy	39%	48%
<b>Transcribing</b> ■ Wrong dose ■ Wrong frequency ■ Missed dose	12%	33%
<b>Dispensing</b> ■ Wrong dose ■ Wrong drug ■ Wrong time	11%	34%
<b>Administering</b> ■ Wrong dose ■ Wrong choice ■ Wrong drug	38%	2%

Adapted from Leape, et al.<sup>3</sup>

- “Wrong choice” errors are mistakes in judgment with regard to the choice of drug or the dose for a patient.
- Transcribing errors result from the misinterpretation of physician orders.
- “Wrong time” errors at the dispensing step typically result from problems with drug stocking or delivery.
- “Wrong choice” and “wrong dose” errors have been found to be the most likely to cause injury.<sup>3</sup>

As shown in Table 2, the majority of medication errors can be attributed to the following factors:

- Lack of knowledge of the drug
- Lack of knowledge of the patient
- Deviations from procedures
- Slips or lapses in memory
- Transcription errors

All of these factors can be addressed through available information technologies. For example, there are several applications that could fill the knowledge gap that is responsible for more than a third of all errors. These modules can increase access to information along the medication use continuum by making available patient-specific information (such as lab values, drug allergies, concomitant medications, and co-morbid conditions), as well as general information (such as usual dosage ranges for a drug, drug interactions, drug incompatibilities, and infusion guidelines). IT can also mitigate other causes of errors by automating or standardizing medication processes or procedures (e.g., by checking doses, allergies, or interactions), increasing process efficiencies, and eliminating extra steps. For example, a technological application could avoid the transcription step by directly transmitting a medication order from the physician to the

pharmacy or by generating medication administration records/schedules from the pharmacy computer system.

Table 2 summarizes some of the common causes of medication errors in a hospital setting and the technologies that address such errors.

It is important to recognize that a single error may have multiple causes as contributing factors. For example, the administration of an incorrect dose of medication—the most common type of error—may have resulted initially from an inappropriate physician order. However, for the patient to receive this incorrect dose, the pharmacist and others involved in each step in the medication use sequence would also have had to miss opportunities to spot the error; for example, the error could have been detected by the pharmacist when verifying the order or by the nurse when checking the dose.

## Why Hospitals Are Considering Technological Solutions

What motivates hospitals to seek out and adopt technological solutions to their problems with medication errors? As more hospitals make a commitment to reducing medication errors, there is growing trend toward the use of IT, whether purchased “off-the-shelf” from vendors or designed internally as a “home-grown” system. In most cases, a combination of internal and external forces is driving hospitals in this direction. This section discusses how these forces can complement each other and how they can sometimes conflict.

### Internal Factors at Play

The primary factor driving hospitals to apply technology to specific steps in the medication use

**Table 2. Technologies That Address Common Causes of Medication Errors**

<b>Cause of Error</b>	<b>% of All Errors</b>	<b>Technologies to Address Cause of Medication Error</b>
<b>Lack of knowledge of the drug</b> (e.g., inadequate knowledge of indications for use, available dose forms, appropriate doses, administration routes and compatibility)	22	<ul style="list-style-type: none"> <li>▪ CPOE, nursing, and pharmacy systems that use a drug information database to provide guidance information and alert clinicians to problems such as improper dosing</li> <li>▪ CPOE with formulary capabilities to direct and reduce choices in medications, dose form, and strength</li> <li>▪ Clinical point-of-care systems with dosing assistance</li> </ul>
<b>Lack of information about the patient</b> (e.g., lack of awareness about relevant patient information such as laboratory test results, conditions, allergies, and current medications)	14	<ul style="list-style-type: none"> <li>▪ Data repositories with access to information provided at the point of care</li> <li>▪ Clinical point-of-care and pharmacy systems with access to critical patient information, including patient allergies, conditions, lab results, medication profile, age, and weight</li> <li>▪ Automated checking that uses critical patient information and a drug information database or clinical rules/algorithms</li> </ul>
<b>Rules violations</b> (e.g., failure to follow accepted and well-established procedures)	10	<ul style="list-style-type: none"> <li>▪ Clinical point-of-care systems that standardize care processes (e.g., treatment protocols, care plans, and dosing schedules)</li> </ul>
<b>Slips and memory lapses</b> (e.g., unexplainable errors or errors due to forgetfulness)	9	<ul style="list-style-type: none"> <li>▪ Data repository that captures and provides information to clinical point-of-care systems</li> <li>▪ Clinical point-of-care systems that standardize care processes (e.g., treatment protocols, care plans, and dosing schedules)</li> <li>▪ Clinical point-of-care systems that incorporate work and task scheduling functions, including reminder, e-mail and other messaging capabilities</li> </ul>
<b>Transcription errors</b> (e.g., errors associated with the order transcription and verification processes that occur because of illegible physician handwriting or a lack of training in order interpretation)	9	<ul style="list-style-type: none"> <li>▪ CPOE with electronic order transmission to pharmacy</li> <li>▪ Electronic document (order) management with transmission of medication order image to pharmacy</li> <li>▪ Pharmacy or nursing systems using a drug information database to check order parameters such as total daily dose and age-appropriate dosing</li> </ul>
<b>Faulty drug identity checking</b> (e.g., errors that result in a patient receiving the wrong medication, confusion with sound-alike names and look-alike packaging)	7	<ul style="list-style-type: none"> <li>▪ Clinical point-of-care and pharmacy system alerts for sound-alike drugs</li> <li>▪ Pharmacy dispensing automation, including robots, counting and packaging devices</li> <li>▪ Automated dispensing carts</li> <li>▪ Nursing systems that use bar code technology to verify that a drug is correct</li> </ul>

**Table 2. Technologies That Address Common Causes of Medication Errors (continued)**

<b>Cause of Error</b>	<b>% of All Errors</b>	<b>Technologies to Address Cause of Medication Error</b>
<b>Faulty interaction (communication) with other services</b> (e.g., problems communicating with other clinicians and errors that occur when patients are in transition between services or units)	5	<ul style="list-style-type: none"> <li>▪ Clinical point-of-care and pharmacy systems that access a common data repository throughout the hospital</li> <li>▪ Clinical systems that incorporate e-mail and automated messaging to the appropriate care provider</li> </ul>
<b>Faulty dose checking</b> (e.g., failure to insure that the proper dose was dispensed or administered)	5	<ul style="list-style-type: none"> <li>▪ Pharmacy dispensing automation, including robots, counting and packaging devices</li> <li>▪ Automated dispensing carts</li> <li>▪ Nursing systems that incorporate medication administration guidelines and alerts</li> <li>▪ Nursing systems that use bar code technology to verify that drug and dose are correct</li> </ul>
<b>Inadequate monitoring</b> (e.g., failure to adjust the dose of a medication appropriately either because necessary monitoring [for blood levels, vital signs, laboratory values, etc.] was not carried out or the changes in the patient were ignored)	4	<ul style="list-style-type: none"> <li>▪ Clinical point-of-care and pharmacy systems that capture vital signs and have access to laboratory results and critical patient information</li> <li>▪ Clinical rules engines that utilize data and algorithms to detect abnormalities and generate alert messages for the appropriate clinician</li> </ul>
<b>Drug stocking or delivery problems</b> (e.g., otherwise unexplained late or missing deliveries of medications to the patient care units)	3	<ul style="list-style-type: none"> <li>▪ CPOE with electronic order transmission to pharmacy</li> <li>▪ Electronic document (order) management with transmission of medication order image to pharmacy</li> <li>▪ Pharmacy dispensing automation including robots, counting and packaging devices</li> <li>▪ Automated dispensing carts</li> </ul>
<b>Preparation errors</b> (e.g., errors in calculation and mixing of drugs that result in incorrect doses)	3	<ul style="list-style-type: none"> <li>▪ Systems that incorporate medication administration guidelines and alerts</li> </ul>
<b>Lack of standardization</b> (e.g., administration errors that result from non-standardized concentrations, dosing schedules, and infusion rates)	2	<ul style="list-style-type: none"> <li>▪ Systems that incorporate medication administration guidelines and alerts</li> </ul>
<b>Other errors</b>	7	

Adapted from Leape, et al.<sup>3</sup>

process is its potential to improve the quality and efficiency of care. But there are several internal considerations and goals that can affect how hospitals approach this task.

One common scenario is that IT solutions for patient safety problems are part of a larger effort to update old systems. Many hospitals today have legacy systems, initially implemented to support the financial and business functions of these organizations. The search for newer information technologies may be initially motivated by the need to replace older patient registration and patient accounting systems; with the recent emphasis on using technology to improve medication safety, hospitals are now looking to select systems that address these needs as well.

*“We were first planning to replace our ADT system...”*

— Medical director involved with design of “home-grown” clinical information system

Hospitals also see IT modules as a way to enhance their current systems. New interfaces, links, and system upgrades can improve existing information systems and their functionality. For example, some hospitals build a pharmacy/laboratory interface to improve access to information that is critical to verifying use of the correct drug and the correct dose. In addition, some IT applications can consolidate patient information from disparate systems into a single source for data collection and reporting purposes, ideally in “real time.” A single clinical data repository, for instance, can provide information on utilization trends in the organization and offer shared access to up-to-date patient information.

### The External Call for Technological Solutions

In addition to their own desire to improve patient safety, hospitals are currently under a great deal of outside pressure to examine how technological applications can help them address the problems associated with medication errors. Both public and private purchasers as well as regulatory authorities are demanding that hospitals take steps to implement technological solutions, most notably computer physician order entry (CPOE), or risk losing licenses or contracts with health care payers.

- The Leapfrog Group, a consortium of large private and public companies that purchase health care benefits for more than 20 million Americans, has identified three hospital safety measures that it encourages health care providers to adopt. Large employers participating in Leapfrog (including California’s Pacific Business Group on Health [PBGH]) are planning to recognize and reward health plans and hospitals that adopt these measures through “preferential use and market reinforcement.” One of the measures is the implementation of computer physician order entry (CPOE) in non-rural hospitals with the goal of reducing the rate of medication errors by 55%.
- The Joint Commission on Accreditation of Healthcare Organizations (JCAHO), which evaluates and accredits nearly 19,000 health care organizations annually, is introducing extensive revisions of its standards in support of patient safety and medical/health care error reduction.<sup>5</sup> Meeting JCAHO standards and gaining accreditation is a requirement for certain Medicare certifications as well as licensure in many states. Its standards already specify some safety issues related to medications (e.g., monitoring and analysis of adverse drug events and drug-food



interactions). JCAHO's standards do not explicitly mandate the use of technology, but various technologies are available to help hospitals meet the intent of the standards.

- Closer to home, Senate Bill No. 1875 requires every general acute care hospital, special hospital, and surgical clinic in California (with the exception of small and rural hospitals) to adopt a formal plan for minimizing medication-related errors as a condition of licensure. This plan, to be implemented on or before January 1, 2005, must include "technology implementation, such as, but not limited to, computerized physician order entry or other technology" to eliminate or substantially reduce medication-related errors.

In addition, hospitals are frequently exposed to medication safety issue thanks to the efforts of professional and special interest organizations, such as the American Hospital Association (AHA), American Society of Health-System Pharmacists (ASHP), Institute for Safe Medication Practices (ISMP), and Institute for Healthcare Improvement (IHI), which have focused a great deal of attention on the problem.

At times, however, the increasing external demands are counterbalanced by internal limitations and barriers. For example, while numerous stakeholders (including payers and special interest groups) advocate CPOE, hospitals may not be in a position to develop or purchase this application because of inadequate funding and/or resistance from physicians.

## **The Role of Information Technology**

In the framework of the medication use process, IT can enhance the delivery of care and improve upon safeguards already in place within an organization. Technology helps to prevent medication errors by organizing information and making it easily available, linking discrete pieces of information, and performing repetitive tasks including checks for problems.<sup>6</sup> For example, automated order entry systems (such as computerized physician order entry) can reduce errors related to medication prescribing and dosing, promoting safe and effective care. Systems that would automate medication ordering, dispensing, and administration processes have also been widely advocated as a strategy for reducing the human contribution to medication errors.

### **Picturing the Ideal System**

In the context of medication use, the ideal IT infrastructure (Figure 2) would include modules that enable clinicians to make the most appropriate decisions about patient care at each step of the process. Specifically, the system should be able to:

- Give users access to shared, "real-time" clinical information at the point of care
- Capture comprehensive clinical data from multiple departments or hospital sites
- Apply automation to care delivery processes related to medication prescribing, dispensing, and administration functions
- Offer users clinical decision support at key points of the medication process

Ideally, a hospital would have a series of systems (e.g., CPOE, pharmacy, laboratory, medication administration) that are all interconnected and can



share data fully in “real time.” These components could be part of a single integrated system or linked through a series of interfaces. Figure 2 illustrates how the various applications or systems bring up data from a data repository by using clinical rules (i.e., decision support tools such as alerts and reminders) that pertain to each step of the medication use process.

### Reconciling the Ideal with Reality

A small number of hospital organizations—the “pioneers” of health care information technology—have spent many years striving for the “ideal IT infrastructure.” A few of them are close to achieving this, having invested many years and significant resources in the design, development, and implementation of various technologies that support this infrastructure.

However, the vast majority of hospitals face serious constraints in the form of limited funding, competing priorities, and the presence of older legacy information systems. Their favored approach is to enhance existing information systems or add technologies in a modular fashion. While that strategy may not be ideal, it is often the most realistic and viable use of available resources.

That said, a modular approach can be seen as a way to work towards an ideal IT infrastructure. At the same time that the organization hones in on a short-term strategy for applying IT modules to attack its biggest problems first (which is what the materials in this tool kit are designed to do), it is critical for hospital leaders to develop a long-term strategy for bringing together the different modules into an integrated system. By keeping this ultimate vision in mind, administrators can ensure that they follow a rational sequence of steps when seeking and adopting technologies to improve medication safety.

## A Review of IT Modules Available at Each Step

This section reviews how hospitals can use specific IT modules to address the errors that can occur at different steps in the medication use process. This list, which is by no means exhaustive, is intended to present those technologies that have been widely described in the literature or adopted by hospitals in recent years. An ongoing example of how a medication order is created, verified, dispensed, and administered through an automated system helps to illustrate the potential value of each of these technologies.

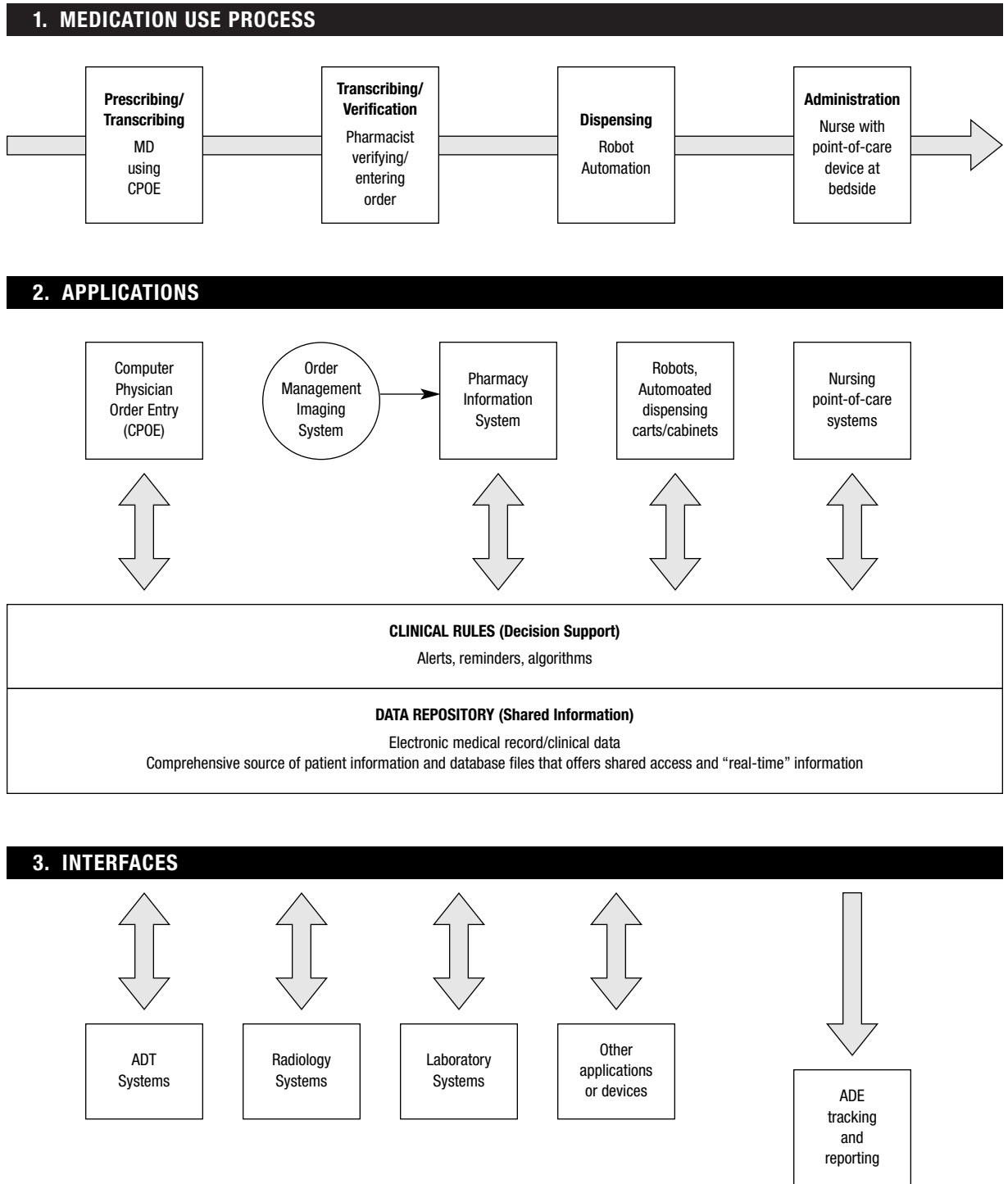
Steps in Medication Use Process	Potential IT Solution
One: Prescribing	Computerized Physician Order Entry
Two: Transcribing/Verifying	Order Management Imaging System Pharmacy Information System
Three: Dispensing	Robots Automated Dispensing Devices
Four: Administration	Point-of-Care Systems

### Step One: Prescribing

#### *Computerized Physician Order Entry (CPOE).*

CPOE is an integrated application that allows clinicians to create orders with the benefit of decision support tools that provide knowledge and guidance while the order is being created, ensuring that patients receive the most appropriate medication and treatment. With CPOE, physicians enter medication orders directly into a computer system. The

**FIGURE 2. Ideal IT infrastructure**



computers may be handheld, on rolling carts, or installed in the patient care areas where physicians would normally “write” orders. The physician can either select medications from pre-selected order groups (based on clinical guidelines or a list of “physician favorites”) or type in medications directly. *Because orders are created by the physician and directly transmitted to the pharmacy, CPOE virtually eliminates transcribing errors.*

The software application incorporates a variety of tools to help physicians, such as alerts, checks, and reminders; treatment protocols; and clinical guidelines. For example, a physician could be guided to order appropriate medications on the basis of embedded guidelines or protocols and can avoid unsafe medications through a series of alerts and checks that are triggered during the ordering process.

CPOE is generally regarded as the option that is most expensive and difficult to implement. Hospitals that have embarked on developing or installing CPOE are anticipated to incur costs running into the millions of dollars, which does not necessarily include expenses associated with training, data conversion, and implementation. But a calculation of the value of this investment depends on the size of the organization and the level of benefits it expects to achieve; for some facilities, CPOE may be the most cost-effective choice. Our interviews identified a few organizations in the process of conducting limited pilot studies or developing/purchasing this capability.

#### *Features that contribute to safety:*

- Order legibility
- Structured ordering with standard order sets
- “Real-time” patient information available at the time of prescribing

- Online drug information support; e.g., dose checking, drug interactions, allergy alerts

### **Case Example: The Technology in Use**

Dr. Green is prescribing an antibiotic for a patient. CPOE gives her access to the following features:

- Decision support from embedded guidelines or protocols that assist Dr. Green in selecting the correct drug, dose, route of administration, duration of therapy, and monitoring parameters
- Clinical decision support that verifies the appropriateness of an antibiotic (for example, as the order is being created, an allergy checking function in the system may catch the patient’s allergy to the antibiotic)
- Access to “real time” clinical documentation about the patient’s condition (e.g., laboratory data online alerts Dr. Green to problems with renal function that could affect dosing, or culture and sensitivity results that could affect drug choice)
- Clinical alerts and checks to verify allergies, dose range, duplicate therapies, and drug interactions (e.g., the order would trigger a drug interaction check, alerting Dr. Green that the patient is on another drug that inactivates the newly prescribed antibiotic)

Once Dr. Green’s online order is complete, the CPOE transmits it to the pharmacy for verification and dispensing.

#### **Step Two: Transcribing/Verification**

*Order Management Imaging System.* These systems provide visual enhancement of a physician’s

hard-copy orders through a scanning process that transmits an image of the order to the pharmacy. The pharmacist can then view the order on a monitor, where it can be enlarged, rotated, and reverse-imaged to improve legibility of the hand-written order. This order does not directly enter the pharmacy system. The pharmacist must interpret the image and enter the information into the pharmacy system. However, this system can be viewed as an interim step to CPOE because of its resemblance to the “real-time” order transcribing and verification capabilities found in CPOE systems.

*Features that contribute to safety:*

- Enhanced legibility of handwritten physician orders
- Reduced turnaround time for orders to be processed (since the image is transmitted immediately from the patient care area to the pharmacy), which prevents medication errors due to delays in administration times
- Reduced disruptions to work-flow processes, preventing errors due to distractions such as phone calls or tracking lost orders

**Case Example:  
The Technology in Use**

Dr. Green has generated a handwritten order for an antibiotic. The following steps take place:

- The clerical or nursing staff scans the order into the order management system, which transmits the image to the pharmacy.
- The pharmacy receives the image, verifies the order with Dr. Green, and enters it into the pharmacy system.

*Pharmacy Information Systems.* Pharmacy information systems are by far the most common order-entry systems; some of the hospital pharmacies interviewed for this report indicated that their systems have been in place for ten years or more. Although these systems had varying degrees of functionality (ranging from patient charge capture to clinical alert triggering), most included a drug database that allowed checks for drug-drug interactions, allergies, and duplicate therapy.

Because of their built-in ability to verify orders, pharmacy systems are perceived to offer the most potential to reduce medication errors. They are frequently the centerpiece of any effort to improve, develop or purchase technologies to improve medication safety. With the exception of CPOE, most information technologies rely on a link to the pharmacy system in order to function. For example, to control access to medications, a hospital may add an automated dispensing cart system that interfaces with the existing pharmacy information system.

A pharmacy information system can function as an independent order entry system that can be used in conjunction with CPOE systems to conduct order verification checks. A “bare-bones” basic pharmacy system will often include a set of checks and alerts (such as allergy, duplicate therapy, and drug-drug interactions). Other triggers that can further expand upon the system’s decision-support capabilities include dose checking and alerts for drug-lab and drug-food interaction. One way to enhance this baseline system is to add a lab interface that brings critical lab information to the pharmacist at the time of order entry or verification. In addition to providing data for online viewing, this interface can provide clinical rules or algorithms that direct the pharmacist to an intervention (e.g., an elevated

potassium level that requires an investigation and probable intervention on the part of the pharmacist). Another useful enhancement is the ability to print medication administration records, which nursing units can refer to for information about patient medications and administration times.

*Features that enhance safety:*

- Double check or verification of prescribed orders
- Structured ordering with standard order sets
- “Real-time” patient information available at the time of order entry (e.g., lab results)
- Online drug information support (e.g., dose checking, drug interactions, allergy alerts)

**Case Example:  
The Technology in Use**

The pharmacy has received Dr. Green's antibiotic order—whether by CPOE, scanned image, faxed transmission, or hard copy.

- The pharmacy staff verifies and enters the order into the pharmacy system. If the hospital has CPOE that is linked to the pharmacy system, this happens automatically.
- The pharmacy system, through a single platform or interfaces, accesses much of the same clinical information and decision support as described for CPOE (alerts, checks, messages).
- Each order becomes part of a database in the system from which medication profiles and medication administration records can be generated, either online or as hard copy.
- The pharmacy system “enables” other technologies that help to reduce errors, including those used in the process of dispensing and administering medications.

**Step Three: Dispensing**

*Robots.* Traditionally used in large-volume pharmacies, these large automated devices use bar coding technology to mechanically “pick” repackaged unit-dose medications, which are then sent to the nursing unit for storage and administration. In conjunction with automated dispensing carts and cabinets and bedside scanners, robotic systems can extend the potential error reduction benefits of bar coded medications beyond routine restocking functions to include bedside verification of patients and medications.

*Features that enhance safety:*

- Automation of the drug selection process, which helps to prevent errors due to human factors (e.g., selecting the wrong drug because of sound-alike and look-alike factors, environmental distractions during the drug selection process)

*Automated dispensing devices.* These devices, which are used by many of the hospitals interviewed for this report, are freestanding carts or built-in cabinets with compartmentalized drawers that contain unit-dose packaged medications. Nurses can access the medications as floor stock (i.e., a pharmacy-verified order is not required) or access may be restricted on a patient-specific basis. Access is usually controlled through the pharmacy information system; that is, the system only allows access to specific medications when there is an active order for the patient that the pharmacist has verified. Once access to the cart is granted (e.g., the nurse enters an identification code, the cart “reads” a thumbprint), a drawer or specific compartment opens to allow access to unit-dose medications. Access to controlled substances is restricted to the release of a single dose. Nurses can activate overrides for predefined “stat” doses for

which prior order verification by the pharmacist is not required.

Although these carts could play a role in reducing medications errors, the primary reason for their introduction is often to prevent drug diversion. However, pharmacists widely acknowledged that, without appropriate safeguards in place, this technology could possibly introduce more errors through unregulated access to medications (e.g., when drugs can be accessed without a patient-specific order) and the use of overrides.

*Features that enhance safety:*

- The ability to restrict access to medications on a patient-specific basis through the pharmacy order verification process
- If linked to order entry systems (CPOE or pharmacy), another “downstream” check on the patient, the drug, and the dose (with the use of bar coding)

Note: If not fully linked or controlled, automated dispensing devices can actually increase the opportunity for error (e.g., by providing access to medications without a verified order).

**Case Example:  
The Technology in Use**

The pharmacy system enters and verifies Dr. Green’s order for an antibiotic, which activates the following functions:

- The system generates bar coded labels for the antibiotic, which the robot uses to “pick” the drug.
- The pharmacy-verified order triggers access to automated dispensing devices (if the drug is allowed to be stored in this device).

**Step Four: Administration**

*Point-of-care systems.* Supported by data generated by a pharmacy or CPOE system, nursing point-of-care applications allow electronic charting, provide access to medication administration schedules, and can offer decision support and guidelines to facilitate clinical decisions at the bedside. They use bar coding technology to check patient wristbands, record the identity of the caregiver, and verify the appropriate medication (with regard to correct drug, dose, frequency, and route of administration). The modules can also create medication administration records that may be accessed by other clinicians involved with the patients’ care.

Several of the hospitals interviewed for this report have turned to these applications, particularly electronic charting and bar coding technology, in order to address errors associated with medication administration (i.e., wrong patient, wrong drug, wrong dose, etc.). However, these technologies are not in widespread use; many of those using nursing point-of-care modules were primarily development sites for the technology.

*“We were looking for an off-the-shelf ‘closed-loop system’ that integrated pharmacy and nursing information.”*

—Senior administrator, small community hospital with nursing point-of-care system

*Features that enhance safety:*

- Access to clinical information at the bedside, at the point of administration, which provides critical information to the nurse (e.g., time that dose was last administered)
- Use of bar coding technology to ensure right patient is being given the right medication ther-



apy at the correct time (e.g., the nurse scans the patient’s wristband to ascertain correct identity and matches it with a bar coded drug whose order has been verified by the pharmacist)

- If linked to other hospital information systems, the potential for “real-time” clinical information at the bedside (e.g., if linked to the pharmacy system, a point-of-care system can provide a list of current medications available to the nurse at the point of administration)

### **Case Example: The Technology in Use**

The verified antibiotic order enables nursing point-of-care systems to do the following:

- Bar coding technology verifies that the right patient is receiving the right dose of the right drug at the right time and using the right route of administration.
- If appropriate, the system triggers alerts and warnings regarding sound-alike or look-alike drugs.
- Handheld devices offer documentation at the bedside.

### **Measuring the Impact of IT Applications**

Unfortunately, information on the “return on safety investment” for IT modules is scarce. Some of these technologies have not yet been widely implemented, and hospitals that have adopted these systems have undertaken only limited measurement of error reduction and cost impact. Also, until recently, very few standards for reporting and classifying errors were in place. However, as systems for reporting and classifying become more readily

available (examples include Internet-accessible standardized databases and a standardized classification of errors), information about the impact of technology on error reduction and costs should be forthcoming.

### **The Impact on Error Reduction: What We Know So Far**

#### *Findings from the Medical Literature*

Some of the better-known results come from early systems development efforts, many of which were models for and, in some cases, precursors of current vendor products:

- **Brigham and Women’s Hospital** in Boston, Massachusetts, was a pioneer in CPOE. It reported a 55% reduction in medication errors (and a 17% decrease in errors harming patients) within 2 years of its 1993 installation of a CPOE system. All inpatient physician orders are captured through this system, which contains alerts, reminders, and clinical decision support interventions.<sup>7</sup> With subsequent refinements, the CPOE system reduced medication errors by 86% from the previous decade.<sup>8</sup>
- **LDS Hospital** in Salt Lake City, Utah, adopted a computer-assisted anti-infective program that offers decision support in the form of suggested agents, dosing regimens (including dosing adjustments based upon laboratory data), and rationale for treatment, as well as checks for allergies and drug-drug interactions. The hospital demonstrated a reduction in the number of orders reflecting excess drug dosages, antibiotic-susceptibility mismatches, and adverse events.<sup>9</sup> The system also significantly reduced drug costs and length of hospital stay for those who received therapies based upon program recommendations.

## The Integration of Disparate Systems

When considering individual technology components to address medication errors, hospital administrators must question how these modules will be incorporated or integrated into a larger infrastructure. One option is to use a single technological platform or “plug and play” approach; another is to adopt a suite of “best-of-breed” applications, which requires that interfaces be built between systems. There is no best answer to this question, although hospitals should seek an answer that both serves the immediate needs of the organization and supports progress towards a long-term vision for well-integrated information systems. That said, hospitals within networks or systems may benefit from a single platform system that facilitates access to shared data. Within a single facility, on the other hand, interfaces between different systems may be sufficient for information exchange.

Some suites of applications are promoted as integrated, but this does not necessarily mean that they run on a single technological platform. In fact, they may be separate systems acquired by the vendor through acquisitions of other health care information systems companies. This patchwork of companies or systems may result in varying levels of “integration” or how information is shared between systems. Two systems that share the same data source or data repository will “see” information differently than two systems that access their data from disparate sources, even though in both instances the systems are interfaced or “talking” to each other.

- Prevention of adverse drug events was the target of the computerized alert system implemented by the **Good Samaritan Regional Medical Center** in Phoenix, Arizona.<sup>10</sup> This alert system used data derived from integrated patient demographic, pharmacy, radiology, and laboratory databases to give clinicians patient-specific information they could use to detect and correct prescription errors that might lead to adverse drug events. During a 6-month period, 53% of triggered alerts were identified as true-positive alerts; they occurred at a rate of 64 per 1000 admissions. Forty-four percent of these alerts were unrecognized by the physician prior to notification. Physician order changes occurred at a rate of 29 per 1000 admissions.

### *Findings from Hospital Interviews*

*“We decreased medications errors by 63% in the first year.”*

— Medical director, large academic medical center with CPOE

Interviews with hospital representatives indicate that hospitals want to demonstrate the effectiveness of technology in reducing medication errors, but that their ability to do so varies widely.

In general, however, hospital organizations seem to have a very limited ability to produce information about the impact of technology on the quality, delivery, and costs of care. Barriers to obtaining this information have much to do with their inability



to collect and track patient clinical data, and the lack of standards for managing this data. Under-reporting and deficiencies in hospital reporting systems also contribute to the dearth of information about the frequency of medical errors. Another factor is the lack of prior experience for most organizations with the use of technology to reduce medication errors. Given these constraints, many hospitals can only estimate the potential benefits of technology by looking at the organization's currently available data—which most interviewees described as inadequate and even inaccurate—as well as published sources of information.

That said, a number of the hospitals interviewed for this report have identified indicators or process measures for future reporting. One hospital with physician order entry (but no decision support) reported a dramatic reduction in medication errors of 63% during the first year of implementation, which it attributed to a decrease in transcribing errors and turnaround times. The presence of a comprehensive clinical data repository was critical to the organization's ability to collect and report on this information. Other hospitals focused on improvements to work processes that could lead to reductions in medication errors simply by enhancing efficiencies in the work environment. For example, one hospital implemented an order management tool to facilitate the transmission of orders from the nursing station to the pharmacy; it reported a dramatic decrease in the number of phone calls that pertained to the order status and location. The hospital believes that this change reduced the risk for errors that could arise from disruptions to work flow resulting from multiple phone calls.

The interviewed hospitals also indicated an interest in conducting:

- Time studies to assess cost savings resulting from technology-driven improvements to workflow processes (e.g., the elimination of MAR [medication administration records] verification with electronic MARs),
- Satisfaction studies targeting patients and users (physicians and clinicians), and
- Cost studies that quantify the impact of adverse drug events or errors on their organizations.

As hospitals gain more experience with the use of IT applications for this purpose, they anticipate that data on their impact on medication errors, clinical outcomes, and workload efficiencies will eventually become more widely available.

### **Impact on Costs**

Information on the cost impact of technologies used to improve medication safety is limited. The Agency for Healthcare Research and Quality (AHRQ) recently published a report that summarizes data on the impact of reduced ADEs on hospital costs and length of stay.<sup>2</sup> It estimates that hospitals can save as much as \$500,000 per year in direct costs by using computerized systems. “Post-event” costs alone have been estimated to be \$4,685 per preventable ADE.<sup>11</sup> Hospitals may also benefit from savings associated with a reduced length of stay, since patients who experience ADEs are hospitalized 8 to 12 days longer than those who do not.

### **Factors that Can Influence a Hospital's Decisions**

Our interviews found that, whether individual sites or a system of hospitals, organizations have chosen to pursue and implement diverse technological solutions to their problems with medication errors.

In addition, nearly everyone has a strategy for investigating or implementing additional technologies in the future. Most hospitals have long-term plans to adopt other forms of technology, most notably CPOE, or enhance current functionality with database integration (e.g., shared information among hospital sites), upgrades (e.g., technologies that allow for “real-time” access to clinical information), or additional features. Other “next steps” include expanded implementation to other patient care areas within the hospital, from inpatient to outpatient settings or vice versa, or to other hospital sites.

*“CPOE is still two years away for us . . .”*

— Pharmacy director, small community hospital with plans to upgrade pharmacy information and implement nursing “profiling” system

What are the considerations that influence these choices? Our interviews found that, while their conclusions may have varied, the primary factors in hospitals’ decisions were remarkably consistent:

- Cost
- Potential or actual impact on medication error reduction
- Ease of implementation
- Vendor relationships

In addition, hospital organizations investigate how existing processes and resources can support the implementation of new or improved technologies. For example, what role can the current pharmacy system play in reducing medication errors? Where do most of the medication errors occur and is there a formal process for evaluating these errors? Where does the solution fit in the organization’s long-term business strategy? The positioning of technology

and how it fits with the overall organizational business plan is also a key consideration in the selection process.

### Cost

Not surprisingly, the most significant considerations for decision makers appear to be the cost of a given technology and the organization’s resource limitations. Funding also appears to be the most important factor in determining how quickly organizations are able to accomplish their goals. For example, although CPOE offers a tremendous opportunity for reducing medication errors, hospitals with CPOE are in the minority. For most hospitals, this technology is still a few years away—a “future initiative”—for reasons primarily related to funding (resistance from physicians is also an obstacle).

Up-front and ongoing costs associated with the purchase of a system generally include the following:

- Software license fee (perpetual license, one-time fee)
- Monthly support fees
- Hardware costs
- Installation fee (for hardware)
- Implementation/consulting costs for system configuration
- Training, including staffing, materials, and other resources

Because product-related costs and fees are typically negotiated between the hospital client and the vendor, specific information was generally not available from vendors. Nor was it provided willingly by interviewees, usually because of contractual or confidentiality obligations. In some cases, costs were difficult to determine because of

developmental partner arrangements with IT vendors that reduced or removed costs normally associated with the purchase of a product or system. Negotiated discounts also complicated efforts to determine the “typical” costs of a type of technology.

### **Impact on Medication Error Reduction**

Most of the interviewees were able to articulate their organization’s medication error “problem areas” and their reasons for selecting specific technological solutions. For example, one hospital discovered that administration errors accounted for 60% of medication errors; it adopted a nursing point-of-care system that included bar coding and electronic medication administration record capabilities.

In many cases, non-technological solutions were already in place, so IT applications were seen as a way to enhance the effectiveness of overall strategies for medication safety. One organization, which was concerned about the potential for lethal errors resulting from inappropriate dosing, gave physicians “dosing pocket cards” in addition to hand-held devices that contain clinical resources.

### **Ease of Implementation**

The selection of IT applications was also influenced by which users were most likely to accept and adopt these solutions. CPOE was generally considered to be the most difficult to implement because of physician resistance to change and the up-front investment of time required to learn how to use the system. Large hospitals with a significant teaching component are best positioned to pursue this route because of the enormous potential for reducing medication errors and their ability to mandate that residents utilize CPOE.

## **One Hospital’s Experience**

One hospital interviewee discussed plans to integrate the current pharmacy and laboratory systems with a hospital-wide information system using a single-source vendor. He perceived that this approach would secure vendor support and enhance the ability of different departmental systems to “talk” with each other. While he was apprehensive about “putting all of his eggs in one basket” with one vendor, he also felt that the quality of interfaces between systems from different vendors was generally lacking because “something was always left behind.”

A related factor is the organization’s level of confidence in the technology. For example, a number of hospitals did not feel that bar coding technology was far enough along in terms of actual implementation sites and packaging support from pharmaceutical companies. Most unit-dose medications (packaged for inpatient hospital use) are not yet coded by manufacturers, and therefore cannot be used effectively with currently available bar coding technologies, such as bedside scanners.

### **Vendor Relationships**

The structure of the relationship between the vendor and the hospital organization also played a role in the selection of technologies, and had a significant impact on the financial considerations. Costs were frequently defrayed or not a factor for hospitals that were development partners or beta sites for IT vendors. In addition, costs associated with building interfaces to other systems could be minimized when a particular vendor’s products and systems were already in place.

## Keys to a Successful Implementation

*“We’re going live all at once—it’s what keeps me up at night.”*

— Medical director, large academic hospital implementing CPOE

The degree to which hospitals are able to successfully implement technologies is variable, depending on the commitment from senior leadership, the availability of resources, user acceptance, and the technological readiness of the organization. In particular, the “buy-in” of hospital administrators is crucial to initiating any movement towards implementing medication error reduction programs, garnering support for medication safety initiatives, or establishing a critical mass of users willing to adopt specific technologies.

In order to achieve and sustain initial and ongoing success, hospitals need to develop a number of strategies that will facilitate the implementation process. These strategies revolve around:

- User training and acceptance
- Pilot site selection and roll-out strategies
- File building and database management
- Hardware, connectivity, and interface requirements
- Vendor performance and support

### User Training and Acceptance

Hospital organizations foster acceptance of IT by users by providing adequate support during training and implementation, as well as targeted education that is customized to the users’ needs. Examples of useful strategies include computer

classes for the “technically challenged,” one-on-one training for physicians, and “roving ambassadors” who are available for troubleshooting and questions in the patient care areas. Physician users typically receive the most labor-intensive training, from side-by-side support from hospital IT personnel to assigned “nurses-in-waiting” who are instructed on how to manage “difficult” physicians.

### Pilot Site Selection and Roll-out Strategies

Because of patient mix, the selection of pilot sites typically leans towards general medical/surgical wards, steering away from high-risk areas such as pediatrics, oncology, or intensive care units. Some hospitals select pilot sites based upon the characteristics of the potential users — i.e., they target sites where users are known to be receptive to the idea of using IT or are intimately involved with the project, such as the nurses who sat on the hospital review committee.

Pilot areas are supported with extra staff members and vendor representatives, sometimes around-the-clock for weeks at a time. Expanded implementation, or roll-out, to other areas tends to be quick and incremental so as to minimize confusion and the potential for problems to arise from the use of different systems in other patient care areas. In many cases, full implementation is not completed for a period of months, regardless of technology. In some cases, duplicate paper systems are maintained for a period of time until the users feel confident with the product.

### File Building and Database Management

Significant resources are required to build and customize database files prior to the implementation of systems that use clinical information,

particularly those that rely on pharmacy data. Depending on the type of system, database building may require several weeks to several months to complete. Interviewees indicated that required staffing resources ranged from one pharmacist for a nursing point-of-care system to an entire “data conversion team” for an integrated hospital system with CPOE.

### **Hardware, Connectivity, and Interface Requirements**

Prior to implementation, hospitals must consider a variety of technological issues, including the financial and technical resources required to upgrade legacy systems and existing hardware in order to accept newer technologies. The interviewed hospitals indicated that they encountered varying degrees of difficulty in interfacing and linking disparate information systems, and that laboratory and pharmacy information systems were the most easily and commonly linked systems.

### **Vendor Performance and Support**

Vendor support before, during, and after implementation varies, ranging from focused services around the go-live period to ongoing onsite assistance. Some vendors provide onsite support well after initial implementation, while others “train the trainer.”

Because the field of health care information technology is still emerging and the adoption of these newer technologies is so recent, vendors that have been primarily focused on product development are now struggling to support widespread implementation. As a result, some vendors are starting to strike alliances with larger companies to broaden their marketing and service support capabilities.

## **In Summary**

While few hospitals can afford to purchase or implement the ideal information system, all hospitals can take steps to ensure that unsafe practices are neither overlooked nor perpetuated. Over time, hospitals should be working towards implementing a comprehensive strategy that combines integrated IT modules with well-established procedures and non-technological measures to prevent errors (such as standard order forms and unit-dose medication systems). Starting with a pharmacy information system that has a basic set of decision-support elements (e.g., checks, alerts, reminders), many hospitals already have a reasonable foundation upon which they can add other systems to enhance hospital-wide medication safety initiatives at each step of the medication use process.

That said, technology is not a panacea. Even a fully integrated system of IT applications cannot address all the causes of medication errors. What technology can do is support and enhance the hospital’s strategy for ensuring medication safety.

In fact, the development and use of rules and procedures to ensure patient safety is critical to the success of technology. Without appropriate safeguards and processes in place to prevent medication errors, the use of technology can actually introduce additional errors or magnify their incidence through automation. For example, if automated dispensing carts are filled incorrectly, the wrong medication may be dispensed to multiple patients. Also, “overrides” and “workarounds” can occur with all forms of technology, negating the benefits that could be derived from their use. For example, a pharmacy information system with allergy checking has limited value if allergy information is not routinely available during order

entry. Similarly, bar coding technology can do little to prevent administration errors due to the “wrong patient” if the patient’s wristband is missing.

The next chapter lays out steps for hospital administrators to follow to identify and select appropriate technologies for their organization. For each step, we provide specific recommendations, a brief discussion of the rationale behind the recommendations, and a list of tools that can support the organization in this effort.

## *Recommendations for Using Technology to Address Medication Errors*

This section outlines a sequence of steps that hospitals can take when planning for and adopting information technology modules to prevent medication errors. For each step, there is a set of recommendations, a list of relevant tools, and a brief discussion of relevant findings from a series of interviews conducted with a diverse group of hospitals that have recently evaluated and implemented technological solutions. The actual tools are provided in the accompanying binder or can be downloaded from the California HealthCare Foundation's Web site (<http://quality.chcf.org>).

To determine the types of technological solutions that are both appropriate and realistic, the hospital must first assess the organization's readiness and its needs with respect to information technologies that can improve medication safety. When doing this, hospital leaders should maintain a broad organizational view that considers the positioning of technology and how it fits within the organization's overall business plan.

Implementation success is tied to user acceptance, which is also critical in determining the types of technologies that will most easily be adopted by the organization. Thus, the second step for hospitals is to prepare users in affected departments and patient care areas, assess barriers to user acceptance, and formulate a plan for identifying, introducing, and rolling out technologies. Once this has been accomplished, the hospital can embark on the third step of evaluating its technological options in light of organizational needs, documented problem areas, and the characteristics of likely users. The final step is to implement the technology.

Taken sequentially, these steps can help hospitals define the technological solutions that best meet its short-term and long-term goals.

### **Step One: Assess the Hospital's Readiness**

**Recommendation:** Conduct an assessment of processes, resources, and strategic goals related to medication and patient safety in order to identify and establish priorities for the most appropriate and realistic technological solutions or enhancements.

#### **Relevant Tools**

- Tool 1. An Assessment of Medication Use Processes
- Tool 2. Medication Error Tracking Form
- Tool 3. Medication Error Reporting Form

In addition, a number of health care organizations have prepared various tools that can assist hospital organizations in creating an environment of increased awareness and establishing baseline process assessments. Examples of such tools are available on the Web sites of the Institute for Safe Medication Practices ([www.ismp.org](http://www.ismp.org)) and the American Hospital Association ([www.aha.org](http://www.aha.org)).

#### **Discussion**

Product selection and evaluation must be based on an analysis of the organization's processes, resources, and strategic focus. An understanding of relevant processes is key to taking the first steps in identifying appropriate technological solutions. A baseline assessment of how information is captured, stored, and accessed can help identify gaps or needs in



particular areas, clarifying which technological solutions offer the most value to the organization and enabling the hospital to set priorities. Processes that require detailed examination include:

- Medication use from order entry to administration (e.g., how are medications ordered, dispensed, and administered and which steps could benefit from automation?)
- Reporting of medication errors and events (e.g., is there an effective process for reporting errors?)
- Analysis of patient care trends and opportunities for improvement (e.g., where are medication errors happening most frequently and what are the sources?)
- Management of patient information (e.g., how are patient records maintained? Are there multiple sources of patient information within the organization?)
- Provider access to decision support at the point of prescribing (e.g., do physicians have access to references, pharmacists, etc., when writing orders?)
- Clinician access to decision support at the point of care (e.g., do pharmacists have ready access to laboratory data as they verify/enter orders?)

Assessments of larger organizational issues would include:

- Overall information system strategy (e.g., what other planned initiatives are in the queue and how are they being supported by IT?)
- Physician relationships with the organization (e.g., are physicians fully employed by the hospital or do they only have admitting privileges?)
- Budgetary constraints (e.g., is there adequate funding to adopt these technologies in terms of purchase or leasing, upgrades to hardware and connectivity?)

## **Step Two: Prepare the Organization; Formulate a Plan**

### **Recommendations**

- Educate all members of the hospital community (providers, patients, and ancillary staff) on medication safety and how existing and new technologies can be used to support efforts to reduce medication errors.
- Begin formulating a plan for adopting technology in the organization by focusing on the pharmacy information system and ensuring that its clinical functionality has been optimized (e.g., clinical checks and alerts are available and activated).
- With regard to ADE reporting, emphasize a non-punitive environment, a multidisciplinary approach, and a commitment to conduct root cause analyses and apply solutions on a system-wide basis—with or without a reliance on technology.

### **Relevant Tools**

Tool 4. A Checklist for Preparing the Organization

### **Discussion**

Before an organization can formulate a plan, whether to implement new technologies or simply improve upon existing systems, it must first create an environment of heightened awareness about medication safety and gain a commitment from the leadership to address issues and processes related to the prevention of errors. Technology alone cannot overcome inadequacies or a lack of systems and processes to support safe and appropriate medication delivery. For example, a consistent failure to obtain and record basic patient information (allergies, height, weight) at the time of prescribing or order entry will not be solved by the use of technology.



Technological solutions should be regarded as just one part of an organization's overall strategy for creating a "culture of safety" that encompasses:

- An adequate understanding of the medication use process within the organization (e.g., how medications are ordered, dispensed, and administered in patient care areas)
- Appropriate safety processes to prevent medication errors (e.g., checking of patient wristbands, documenting of allergy information)
- A baseline assessment of where there are opportunities for improvement (e.g., areas where medication errors occur most frequently)
- A plan for educating patients and staff members alike on medication safety

All members of the hospital community—providers, patients, and ancillary staff—need to understand how existing and new technologies can be used to support rather than replace existing efforts to reduce medication errors (e.g., the use of clinical decision-support tools). In addition, staff education should include the recognition of "unsafe" practices that can lead to medication errors (e.g., using abbreviations in the ordering of chemotherapy agents).

As part of this step, many of the interviewees formed medication safety teams and process improvement teams; they also involved the traditional Pharmacy and Therapeutic Committees and medication use evaluation teams for the purpose of addressing patient safety initiatives at an organization-wide level. These multidisciplinary teams and committees can bring key lessons and messages to affected departments and patient care areas through the use of staff education and process improvement programs. Teams usually include physicians, nurses, pharmacists, and other patient

care staff who can champion the adoption of technologies and changes to "the way things are done" at the user level. For one hospital, the presence of review committee members in a particular patient care area was key to its selection as a pilot site for a nursing point-of-care system.

Multidisciplinary "buy-in," which is also critical to gaining hospital-wide support, has to come from the senior management level. One hospital interviewee reflected on how the leadership team at his hospital placed other projects on hold while CPOE was being implemented.

### **Step Three: Evaluate and Select Technological Solutions**

#### **Recommendations**

- Conduct a detailed examination of the steps involved in preparing the organization technically for system implementation *prior* to product selection.
- Define the organization's expectations for vendor support and mandate a response to these expectations during the request for proposal (RFP) process.
- Since pharmacy information systems are widely available and implemented in many hospitals, they should be the initial focus for improvement or replacement. These systems are also the "hub" from which other technologies are enabled and added in a modular fashion, including CPOE.
- Enhance the functionality of the pharmacy information system by building a link to the laboratory system, so that laboratory information is available to the pharmacist during order entry.
- Implement an order management imaging system that helps to prevent errors related to

illegible orders and improve workload efficiencies in the pharmacy (as a result of fewer phone calls and interruptions).

- Once pharmacy information systems are fully functional, adopt automated dispensing carts that can only be accessed upon order verification by the pharmacist (with the exception of carefully selected “emergency” drugs).
- Consider CPOE only if the organization has the financial and manpower resources available to appropriately manage the implementation process and mandate its use.
- If CPOE is implemented, link it to pharmacy information systems for order verification and nursing point-of-care systems (if available) in order to maximize the potential for reducing medication errors at each step of the medication use process.

#### Relevant Tools

Tool 5. A Guide to Potential IT Solutions to Medication Errors

Tool 6. Pros and Cons of IT Options

Tool 7. Needs Assessment and Product Evaluation

Tool 8. Request for Proposal (RFP) Template

Tool 9. Estimated Cost Savings Worksheet

#### Discussion

Options for technological solutions can include augmenting, improving, or replacing current systems in a stepwise, modular fashion. The determination of which option is most appropriate and realistic for the organization is a function of the organization’s needs, the organization’s commitment to reducing medication errors, and an understanding of the user characteristics that will drive implementation success and acceptance of IT.

## Step Four: Implement Technologies

#### Recommendations

- Allocate adequate resources to build and customize database files, regardless of the type of system.
- Prepare for intensive training and utilization of resources during the implementation of systems that require significant involvement from physicians (particularly CPOE).
- Allow for adequate staffing support and prepare an aggressive roll-out schedule.

#### Relevant Tool

Tool 10. An Example of the Implementation Process

#### Discussion

Hospital interviewees strongly supported the need to obtain administrative “buy-in” before initiating any movement towards implementing medication error reduction programs, including the use of technology. “Laying the groundwork” includes establishing medication safety initiatives and building a critical mass of users willing to adopt these technologies.

To facilitate implementation, hospitals need to develop a number of strategies to address user training and acceptance, program rollout, and preparation of the system or product for implementation in order to achieve and sustain initial and ongoing success. Adequate vendor service and support is another determinant of implementation success.

## Going Through the Four Steps: Two Examples

### First Example: Hospital A

Bed Size	261
Type	Community
Technology in place	Pharmacy system (linked to lab system), automated dispensing carts
Technology being implemented	“Profiling” feature to be added to automated dispensing carts (allows access only with pharmacy-verified order)
Step One: Organizational assessment	<ul style="list-style-type: none"> <li>▪ Physician prescribing is source of most errors, but not necessarily the most dangerous</li> <li>▪ Medication administration identified as an area that could benefit from the use of improved technology                             <ul style="list-style-type: none"> <li>– “Loopholes” and “overrides” creating problems with automated dispensing carts (e.g., access allowed to medications without verified order)</li> <li>– Outdated, hard copy MARs identified as source of “worse” errors (e.g., continued heparin administration after order was discontinued)</li> </ul> </li> </ul>
Step Two: Preparation of organization	<ul style="list-style-type: none"> <li>▪ Pharmacy director was driver for implementation</li> <li>▪ Enlisted support from nursing administration</li> <li>▪ “Sold” staff nurses (users) on patient safety</li> <li>▪ Promoted compliance with JCAHO safety standards</li> <li>▪ Enlisted pharmacist staff support as well (e.g., reinforced “good image” of pharmacists as supporters of patient safety)</li> </ul>
Step Three: Evaluation and selection of technologies	<ul style="list-style-type: none"> <li>▪ Needed to address problems with administration</li> <li>▪ Decided against bar coding technologies because of limited supply of bar coded unit-dose drugs</li> </ul>
Step Four: Implementation of technologies	<ul style="list-style-type: none"> <li>▪ Training support slim – “trained the trainer”                             <ul style="list-style-type: none"> <li>– Members of multidisciplinary patient safety committee assigned to conduct training</li> <li>– Vendor support for training limited</li> </ul> </li> <li>▪ Pharmacy preparation extensive because of database building to support allowed “overrides” (e.g., “stats”, emergency drugs)                             <ul style="list-style-type: none"> <li>– “Overrides” customized to each nursing unit</li> <li>– One pharmacist assigned to manage software</li> </ul> </li> <li>▪ To “go live” all at once</li> </ul>
Next steps	<ul style="list-style-type: none"> <li>▪ Considering CPOE, but still two years away                             <ul style="list-style-type: none"> <li>– Physicians are 100% private</li> </ul> </li> <li>▪ Would upgrade pharmacy system if part of a comprehensive integrated hospital system</li> </ul>

## Going Through the Four Steps (continued)

### Second Example: Hospital B

Bed Size	400
Type	Community
Technology in place	Pharmacy system
Technology being implemented	Upgrade a 20-year-old pharmacy system unable to perform basic operational functions (e.g., medication labeling)
Step One: Organizational assessment	<ul style="list-style-type: none"> <li>▪ Safeguards and processes for optimal dispensing of medications not in place, with little support from pharmacy system (e.g., order entry of dispensed medications not consistently performed because of system inadequacies, handwritten medication labels)</li> <li>▪ Pharmacy system in need of improvement as current level of functionality not regarded to be safe (e.g., drug database, including system alerts and checks, not updated)</li> </ul>
Step Two: Preparation of organization	<ul style="list-style-type: none"> <li>▪ Newly appointed pharmacy director was driver for implementation of process changes, as well as new technology</li> <li>▪ Changes to pharmacy operations required “culture change” for both pharmacy and nursing staffs</li> <li>▪ Medication safety awareness slowly being promoted through efforts of multidisciplinary committee</li> </ul>
Step Three: Evaluation and selection of technologies	<ul style="list-style-type: none"> <li>▪ Selected pharmacy system with graphical interface and ability to communicate with other systems</li> <li>▪ Looked for depth of implementation at other sites</li> </ul>
Step Four: Implementation of technologies	<ul style="list-style-type: none"> <li>▪ Planning a 12-month implementation process (including preparation of drug database, to be absorbed by current staffing)</li> <li>▪ Still in the process of finalizing purchase</li> <li>▪ During evaluation process, vendor was acquired by another company creating some initial challenges in contracting with the parent company</li> </ul>
Next steps	<ul style="list-style-type: none"> <li>▪ Electronic MAR for nurses likely to follow</li> </ul>

# Appendices

## Appendix A: Methodology

Protocare Sciences conducted primary and secondary research to gather information on the problem of medication errors, the use of health care information technology and other strategies to address this problem in the hospital setting, and related trends and events affecting hospitals both within and outside of California.

### Secondary Research

Using a Medline database search and sources identified in the IOM's report on medical errors, Protocare identified key articles in the medical literature as well as other important secondary sources such as special interest and professional society publications. Protocare also searched specific Web sites to gain access to publications from professional organizations (e.g., American Society of Health-System Pharmacists) and special interest groups and coalitions (e.g., Institute for Safe Medication Practices, Massachusetts Coalition for the Prevention of Medical Errors).

### Primary Market Research

Protocare conducted a total of 33 interviews by phone, at professional meetings, and onsite. The objectives of the interviews were to:

- Identify the key factors that influence the decision-making process involved in selecting and implementing technologies aimed at reducing medication errors.
- Understand how hospitals have overcome the major issues and challenges surrounding the

implementation of technologies to prevent medication errors in a hospital setting; i.e., to identify the lessons learned by organizations that have worked through the process of choosing and preparing for new technologies.

- Find evidence to support the strategy of using a sequential approach to adopting technology modules that address medication errors.

In general, the interviewees indicated that the use of information technology in the hospital setting is not new; in fact, many of the organizations interviewed had systems in place for at least the past decade. Their motivations and the barriers they encountered were similar, as were the approaches they used to select and implement information systems. However, the sites varied widely in the scope and type of technologies selected and the decisions made regarding those technologies.

### Interviews with Hospitals and Hospital Systems:

Through telephone and onsite interviews, Protocare gathered information from senior-level hospital directors and administrators at 15 individual hospitals (which may also be part of a hospital chain or health care system). These hospital leaders included medical directors, pharmacy directors, nursing administrators, and chief information officers from both hospital system and local hospital organizations, with a mix of community and academic environments. Basic information about these sites is presented in Table A-1.

Protocare identified hospital interviewees through IT vendor-customer relationships, from secondary source publications, and through external sources

familiar with hospital organizations that have implemented information technologies. There was an emphasis on identifying “mid-sized” community-based hospitals, both within California and outside the state, that were in the process of implementing or had implemented some form of information technology because the goal was to approach medication errors in the context of the “average” hospital.

The hospital representatives discussed their motivations and the challenges they faced in adopting information technologies. Protocare used findings from these interviews to develop a set of recommendations that reflect respondents’ experiences and the lessons they learned.

**Interviews with Hospital Associations:** In addition to these interviews, Protocare also consulted with seven key representatives of hospital chains, hospital systems, and national and state hospital associations. The goal was to gain insight into the larger issues hospitals as a group are facing with respect to medication safety and the use of technology.

**Interviews with Vendors:** Protocare interviewed representatives of eleven IT vendors between December 2000 and April 2001 (not including additional product demonstrations). Table A-2 provides their titles and organization names. The goal in selecting IT vendors for interviews was to choose those with a strong presence in the hospital marketplace. This assessment was based on findings in IT trade publications, and attendance at professional society and industry organization meetings.

**Table A-1. Hospital (Individual Site) Interviewees**

<b>Beds</b>	<b>Type</b>	<b>Location</b>	<b>Interviewee Title(s)</b>	<b>Technology Implemented</b>
24	Community	California	Director of Inpatient Services	Considering CPOE
261	Community	California	Director of Pharmacy	Pharmacy information system with automated dispensing cart
291	Community	California	Director of Pharmacy	Order management imaging system (scanner), pharmacy information, and automated dispensing carts
380	Community	California	Pharmacy Manager	Pharmacy information systems with automated dispensing carts
400	Community	California	Director of Pharmacy	Converting pharmacy information system under a hospital system corporate initiative
1,120	Academic	California	Director of Technology and Architecture, Director of Pharmacy	Developing “home-grown” integrated patient management and order entry system with decision support
136	Community	Pennsylvania	Clinical Pharmacist	Nursing medication administration with bar coding
166	Community	New York	Director of Pharmacy	Implementing comprehensive information system: CPOE, pharmacy, and nursing point-of-care
307	Community (rehab)	Toronto, Canada	VP of Patient Care Services, Project Manager	Pharmacy information system linked to nursing point-of-care
350	Community	Wisconsin	Nursing Director, Director of Pharmacy	Bar coding and nursing point-of-care
442	Community	New York	Director of Pharmacy	Pharmacy information system, nursing medication administration
570	Academic	Hawaii	Manager of Clinical Applications, Medical Director, Clinical Informatics	Implemented CPOE
622	Academic	Pennsylvania	Chief Medical Officer, Assistant Pharmacy Director, Director of Performance Improvement	Recently implemented pharmacy information system, implementing CPOE this year. Using dispensing robots.
654	Academic	Massachusetts	Chief Information Officer	Implementing CPOE, patient-centered Web site
697	Community	Arizona	Director of Patient Care Systems, System Director of Clinical Applications, Manager Pharmacy QA/Risk Management, System Manager	Pharmacy information system with order transcription, nursing point-of-care, and automated dispensing carts

**Table A-2. IT Vendor Interviews**

<b>Company Name</b>	<b>Contact</b>	<b>Technological Products</b>
Alaris Medical Systems, Inc.	Director, Medication Management Systems	IV infusion pumps
Autros Healthcare Solutions, Inc.	Regional Director	Point-of-care medical management system and physician order entry system
Bridge Medical, Inc.	Senior management team	Nursing point-of-care systems with bar code verification
Cerner Corp.	Director, Clinical Trials and Data	Suite of health care information systems
Eclipsys Corp.	Medical Director	Suite of health care information systems
IDX Systems Corp.	Product Development Manager	Suite of health care information systems
McKessonHBOC, Inc.	Vice-President, Marketing	Suite of health care information systems and robotics, bar code verification
Meditech, Inc.	Regional Manager	Suite of health care information systems
Pyxis Corp.	Manager, Pharmacy Logistics Products	Automated medication and supply controlled-access systems, order management imaging systems
Siemens Medical Solutions Health Services Corp.	Director, Corporate Communications	Suite of health care information systems
3M Health Information Systems	Medical Director	Suite of health care information systems



## Appendix B: Vendor Profiles

Table B lists the vendors that participated in the research conducted for this tool kit and indicates which aspects of the medication use process their products address. The table is followed by detailed profiles of eight of the individual companies and their services based on both publicly available materials as well as information provided by the vendors. Please contact vendors directly for additional information regarding specific products.

These profiles do not represent an endorsement of the companies or their products, but are included for informational purposes only. Hospitals must conduct a careful and detailed evaluation in order to select a vendor and product that meet their needs.

This section is directed at hospital decision makers and other leaders in the organization.

**Table B. Vendor/Product Categories**

VENDOR NAME	PHYSICIAN ORDER ENTRY: PRESCRIBING	TRANS- CRIBING	PHARMACY ORDER ENTRY: VERIFICATION	DISPENSING	NURSING ADMINI- STRATION	BAR CODE
<b>AUTROS HEALTHCARE SOLUTIONS, INC.*</b> WWW.AUTROS.COM	✓	✓	✓	✓	✓	✓
<b>BRIDGE MEDICAL, INC.*</b> WWW.BRIDGEMEDICAL.COM					✓	✓
<b>CERNER CORP.*</b> WWW.CERNER.COM	✓	✓	✓	✓	✓	
<b>ECLIPSYS CORP.*</b> WWW.ECLIPSYS.COM	✓	✓	✓		✓	
<b>IDX SYSTEMS CORP.*</b> WWW.IDX.COM	✓	✓	✓		✓	
<b>McKessonHBOC, Inc.*</b> WWW.MCKHBOC.COM	✓	✓	✓	✓	✓	✓
<b>MEDITECH, INC.*</b> WWW.MEDITECH.COM		✓	✓		✓	✓
<b>PYXIS CORP.*</b> WWW.PYXIS.COM		✓		✓	✓	✓
<b>SIEMENS MEDICAL SOLUTIONS HEALTH SERVICES CORP.</b> WWW.SMED.COM	✓	✓	✓		✓	✓
<b>3M HEALTH INFORMATION SYSTEMS</b> WWW.3MHIS.COM					✓	

\*Vendor profile listed in this section

## **AUTROS Healthcare Solutions Inc.**

1 Yorkdale Road, Suite 310  
Toronto, Ontario, Canada  
M6A 3A1  
800-537-2255  
<http://www.autros.com>

### **Company History**

AUTROS, a privately held company, has been in operation since 1992. Its AUTROS Inpatient System has been available in the United States since December 1998. The foundation of the technology is the MEDI-Trust Outpatient/Mail Order Pharmacy System, Canada's national pharmacy service.

### **Product Breadth**

The product range (as a fully integrated product suite or separate modules) incorporates the use of bar coding and wireless technology at each step of the medication use process, from prescribing to administration. Prescriber and nursing applications are supported with clinical decision-support tools.

<b>Product Description</b>	
<b>Product Name</b>	<b>Description</b>
Point-of-Care	<ul style="list-style-type: none"><li>■ Computerized prescribing, electronic MARs and charting</li><li>■ Bar coding (for medication administration) and "real-time" technology</li></ul>
Patient Connect	<ul style="list-style-type: none"><li>■ Two-way wireless pager system that integrates with the Point-of-Care System</li><li>■ Prompts home-care patients to take their medication at the prescribed time and monitors compliance</li></ul>
MD Connect	<ul style="list-style-type: none"><li>■ Physician order entry system</li><li>■ Orders transmitted via Internet</li><li>■ Can run on handheld devices and PC workstations</li></ul>
Scriptlink	<ul style="list-style-type: none"><li>■ Pharmacy information system</li><li>■ Capable of profiling, order screening and internal messaging, and supporting distribution</li></ul>
Electronic Charting	<ul style="list-style-type: none"><li>■ Nursing point-of-care system</li><li>■ Utilizes wireless handheld devices</li></ul>
Infant Track	<ul style="list-style-type: none"><li>■ Pediatric application under development</li><li>■ Expected release mid-2001</li></ul>

### AUTROS — Implementation Steps

Module (Product Name)	Increment	Months to Implement	Relative Difficulty*	Relative Cost**
Point-of-Care Med Management System	1	3	L	
—Script Link – Inpatient Pharmacy Module				5
—Point-of-Care Nurse Charting				4
—Point-of-Care MD Connect-POE				3
Clinical Track	2	1	L	2
Infant Track	3	1	L	1

\*Relative difficulty: Low (L), Moderate (M), High (H)

\*\*Relative cost: 1 (lowest) to 5 (highest)

#### Vendor services offered

- Implementation assistance
- Implementation guide
- Personnel onsite
- Training onsite
- Training manuals
- Software issues and enhancements tracking
- Web-enabled
- 24/7 emergency support
- Data loading assistance

#### High-level technical architecture that would be employed for a 300-bed community hospital:

- Open architecture
- Uses real-time TCP/IP
- Oracle relational database
- Windows NT cluster dual processor database server
- Dual processor NT application servers
- Workstations operate in client/server mode. Application code runs on each workstation. There are also thin client and Web-enabling options. Information is presented in Windows-based format but can also operate in a “Web browser” mode. Hardware: 250MHz or higher, 32MB RAM adequate, 64 recommended, 50MB Hard Disk space, SVGA 800x600 display, 1024x768 or higher recommended, operating system: Windows 95/98 or NT Workstation
- Wireless handheld devices (Symbol Technologies—minimum 8x20 screen) with integrated bar code reader. Uses RF (radio frequency) using IEEE 802.11 wireless standard. Devices continually poll the server so information current. They run browser software
- Wireless, mobile inventory med depots (can also interface with other vendors)
- AUTROS supports HL7 interfaces and, although not a firm requirement, recommends an interface engine
- PC Anywhere
- First Data Bank (Medispan) drug database

## Bridge Medical, Inc.

120 South Sierra  
Solana Beach, CA 92075-1811  
858-350-0100  
<http://www.bridgemedical.com>

### Company History

Bridge Medical, Inc., founded in 1996, focuses on medication administration and charting products that utilize bar code verification. In February 2001, Bridge Medical joined Pyxis Corporation in an agreement, whereby Pyxis will provide installation and support services for the MedPoint™ product.

### Product Breadth

Product supports medication administration, nursing care documentation, and care analysis processes.

### Product Description

The MedPoint™ medication management system, first installed in a hospital in 1998, focuses on medication administration. This product utilizes bar code technology, incorporating clinical decision support, medication error reporting, documentation, and audits. The system is modular and interfaces with existing hospital and clinical information systems as well as pharmacy distribution systems. Radio frequency is utilized to provide real-time information updates.

Upcoming software releases this year include a Web client, a handheld application, alerts based on lab results, a data warehousing solution, and a discharge medication module. A pediatric module, infusion pump integration, and applications to be used in skilled nursing facility, home health, and outpatient settings are planned for 2002.

<b>Bridge Medical — Implementation Steps</b>				
<b>Module (Product Name)</b>	<b>Increment</b>	<b>Months to Implement</b>	<b>Relative Difficulty*</b>	<b>Relative Cost**</b>
MedPoint™	Base system	6	M	2-3
*Relative difficulty: Low (L), Moderate (M), High (H)				
**Relative cost: 1 (lowest) to 5 (highest)				

### Vendor services offered

- Implementation assistance
- Implementation guide
- Personnel onsite
- Training onsite
- Training manuals
- Software issues and enhancements tracking
- Web-enabled
- 24/7 emergency support
- Data loading assistance

### High-level technical architecture that would be employed for a 300-bed community hospital:

- Open Multi-tier Client Server Architecture
- Uses real-time wired or wireless TCP/IP
- MS SQL Server database
- Server: NT, C++, COM, CORBA, XML; NT Server, 1.5 Gigabytes of RAM, 3+ Gig Data Storage
- Applications utilize CCOW/ HTML Templates. Hardware: 166MHz or higher, 64MB RAM or higher, Optimized for touchscreen tablets or touchscreen notebooks. Operating system: Windows 95/98/2000 or NT
- Wireless handheld devices (Symbol Technologies) with integrated bar code reader; uses RF (radio frequency) using IEEE 802.11 wireless standard
- Interface transactions utilize Cloverleaf Engine, XML, HLT
- API: C++COM, CORBA
- First Data Bank drug database
- Crystal reports

## Cerner Corporation

2800 Rockcreek Parkway  
Kansas City, MO 64117  
816-221-1024  
<http://www.cerner.com>

### Company History

Cerner Corporation, founded in 1979, offers a suite of clinical information systems that, when integrated, can provide for enterprise-wide health care information processing. The cornerstone of Cerner's information systems strategy is the single architecture.

### Product Breadth

The first system development was for the laboratory information system, PathNet. Since then, Cerner has introduced products for internal medicine, radiology, pharmacy, surgery, medical records, emergency departments, intensive care units, physicians, and nurses, as well as products that facilitate the computer-based patient record.

## Cerner Corporation

Product Name	Description
PharmNet Medication Safety System	<ul style="list-style-type: none"> <li>■ Pharmacy order entry</li> <li>■ Integrates with Cerner's laboratory information system or, through a foreign system's interface, with many other lab systems; also patient management and finance systems</li> <li>■ Has the ability to allow review of administered medications, lab results, and other clinical information available in the repository</li> </ul>
Adverse Drug Event (ADE) Safety Package	Computerized decision-support system (with client-defined clinical rules)
Electronic Medication Administration Record (MAR) with Vitals Documentation	Facilitates flow of medication order and administration to and from the point of care
Bedside Medication Administration	<ul style="list-style-type: none"> <li>■ Alternative approach that employs the use of wireless portable devices to perform the tasks at the bedside</li> <li>■ Future versions of this product will include Palm™ handheld devices with positive patient identification, positive drug identification, and other features enabled by bar coding</li> </ul>
CareNet Order Management	Coordinates multi-disciplinary order communication
Computerized Physician Order Entry	In testing
Medication Safety Reporting	For monitoring process variations and patient safety outcomes
Medication Process Integration	"Closes the loop" between the pharmacy system, order management, and MAR – available mid-2001
Advanced Bedside Patient Safety Alerts	Cumulative dose alerts and prompts that can be forwarded to nursing pagers to ensure timely patient assessment while on therapy (expected release first quarter of 2002)

## Cerner — Implementation Steps

Module (Product Name)	Increment	Months to Implement	Relative Difficulty*	Relative Cost**
PharmNet Medication Safety Package	1	6	L	N/A
Adverse Drug Event (ADE) Safety Package	1	Implemented in parallel with pharmacy system	M	N/A
Electronic MAR with Vitals Documentation	2	2	L	N/A
Bedside Medication Administration	3	2	M	N/A
Advanced Bedside Patient Safety Alerts	3	In parallel with Bedside Admin	M	N/A
CareNet Order Management	4	4	M	N/A
Computerized physician order entry	4	In parallel with CareNet	H	N/A

\*Relative difficulty: Low (L), Moderate (M), High (H)

\*\*Relative cost: 1 (lowest) to 5 (highest)

### **Vendor services offered**

- Implementation assistance
- Implementation guide
- Personnel onsite
- Training onsite
- Training manuals
- Software issues and enhancements tracking
- Web-enabled
- 24/7 emergency support
- Data loading assistance

### **High-level technical architecture that would be employed for a 300-bed community hospital:**

- Open architecture
- Uses real-time TCP/IP
- Oracle relational database
- Compaq Nonstop Servers
- Dual processor NT application server
- Workstations operate in client/server mode. Application code runs on each workstation. Information is presented in Windows-based format but can also operate in a “Web browser” mode. Hardware: 333MHz or higher, 64MB RAM, 100 MB Hard Disk space, SVGA 800x600 display, operating system: Windows 95/98 or NT Workstation 4.0 or newer.

### **Minimum Workstation Hardware**

- Intel-based mid-range workstation (or Cerner-approved equivalent)
- Local Bus Video
- 3.5” floppy drive (optional)
- 128 MB memory for Windows 95C, Windows 98, or Windows NT 4.0, SP5
- 800 MB available hard drive space for Cerner application code or local Cerner application cache
- Graphics resolution of 1024x768 with 256 colors
- 101-key keyboard and mouse or equivalent
- Some Cerner applications require additional items. Details are available from Cerner.

### **Network Requirements**

- Winsock 1.1 or higher compliant TCP/IP protocol stack
- Ethernet 16-bit network card or higher
- Each PC must have a valid IP address
- Wireless handheld devices (Symbol Technologies—minimum 8x20 screen) with integrated bar code reader. Uses radio frequency (RF) using IEEE 802.11 wireless standard. Devices continually poll the server so the information is current. They run browser software.
- Multum drug knowledge base



## Eclipsys Corporation

777 E. Atlantic Ave., Suite 200  
 Delray Beach, FL 33483  
 561-243-1440  
<http://www.eclipsys.com>

### Company History

Eclipsys was formed in December 1995 by Harvey J. Wilson, a founder of Shared Medical Systems. Eclipsys grew as a company primarily through a number of acquisitions that took place from 1997 through 1999. Eclipsys went public in August of 1998. In July 1999, Eclipsys and VHA, Inc., in conjunction with General Atlantic Partners, LLC, formed a new privately owned joint-venture health care Internet company, HEALTHvision, Inc.

<b>Eclipsys Corporation</b>	
<b>Product Name</b>	<b>Description</b>
Sunrise Clinical Manager clinical management suite	<ul style="list-style-type: none"> <li>■ Includes real-time, rules-based clinical decision support and asynchronous clinical decision support; order communication and management; multidisciplinary clinical documentation; physician office documentation and workflow; disease-management care documentation</li> <li>■ Incorporates an electronic patient record, order entry, and a clinical data repository</li> <li>■ Can be used standalone or interfaced with the hospital ADT, lab, transcription system, or any other hospital system that meets interface requirements</li> <li>■ Clinical documentation is an add-on module</li> </ul>
Sunrise Knowledge-Based Orders	<ul style="list-style-type: none"> <li>■ Basic order entry functions</li> <li>■ Developed for physician order entry but allows order entry by other individuals with clinical decision support</li> <li>■ Can be used as a standalone order entry system or interfaced to an existing pharmacy system</li> </ul>
Sunrise Disease Manager—Oncology	An oncology-specific product that incorporates an electronic patient record, order entry, and a clinical data repository
Sunrise Critical Care	Clinical care charting tool that facilitates and automates the electronic documentation of patient care
Sunrise Universal Viewer	Enables clinician access to a variety of data types and sources including laboratory, microbiology, radiology results, blood band and pharmacy data, transcription services, ADT data, and order status
Sunrise Decision Support Manager	<ul style="list-style-type: none"> <li>■ A central data repository that collects information from throughout the enterprise</li> <li>■ Incorporates analytical tools that support financial and clinical decisions</li> </ul>

### **Product Breadth**

Eclipsys offers an integrated clinical management system that includes both real-time and asynchronous clinical decision support (see previous page).

### **Implementation Steps**

N/A

### **Vendor service checklist**

N/A

### **High-level technical architecture that would be employed for a 300-bed community hospital:**

- Sunrise Clinical Manager 3.01 with appropriate servers
- SCM Hardware:
  - Primary Active ServerReport/Multum ServerHL7 Server
  - Enterprise CDS Server
  - EAI Server (Enterprise Application Integration Manager)
- All Sunrise applications communicate via Health Level Seven (HL7) 2.x standards; the standard interfaces are provided with the Sunrise software purchases
- The main servers for this application are NT based with SQL 7.0

## **IDX Systems Corporation**

40 IDX Drive  
P.O. Box 1070  
Burlington, VT 05402-1070  
802-862-1022  
<http://www.idx.com>

### **Company History**

IDX, a publicly held company, was founded in 1969. In 1997, IDX merged with PHAMIS, Inc., developer of the LastWord® clinical system, which automates core clinical functions for acute care facilities. The company's product offerings include clinical, financial, and administrative solutions, as well as consulting services.

### **Product Breadth**

The LastWord system integrates core clinical processes to support care management. In the LastWord system, a patient record is created through the automation of the workflow processes that include clinical, financial, and administrative functions throughout the enterprise.

## IDX Systems Corporation

Product Name	Description
LastWord® Orders	<ul style="list-style-type: none"> <li>■ Order entry system for physicians, clinicians, clerks, and pharmacists</li> <li>■ Provides alerts and clinical rules feedback</li> <li>■ Electronically transmits orders via the Internet</li> <li>■ Provides an audit trail for order entry and revisions</li> </ul>
LastWord® Care Documentation	Offers charting and worklist tools to support documentation
LastWord® Expert Systems	Provides decision support and allow the creation of a library of clinical rules, developed through the shared knowledge of IDX and client institutions
LastWord® Foundation	Includes components of electronic medical record used in conjunction with online ordering, including patient registration, Admission-Discharge-Transfer, and medical record
Integrated alert routing to pagers and e-mail	Under development
Barcode scanning	Under development

## IDX Systems — Implementation Steps

Module (Product Name)	Increment	Months to Implement	Relative Difficulty*	Relative Cost**
Foundation	1	12–14 (recommend concurrent install with other modules)	L	1
Physician Order Entry/ Order Communication/Inpatient Pharmacy	1	12–14	H	3
Clinical Documentation	2	12–14	H	4
Expert Systems	3	3–6	N/A	N/A

\*Relative difficulty: Low (L), Moderate (M), High (H)

\*\*Relative cost: 1 (lowest) to 5 (highest)

### Vendor services offered

- Implementation assistance
- Implementation guide
- Personnel onsite
- Training onsite
- Training manuals
- Software issues and enhancements tracking
- Web-enabled
- 24/7 emergency support
- Data loading assistance
- Other (day-to-day support team)

### High-level technical architecture that would be employed for a 300-bed community hospital:

The LastWord system architecture offers a thin client, three-tiered client server model, with a Web interface accessible through any device that supports a browser. The IDX LastWord system includes the following technical components:

- Open Architecture: IDX LastWord utilizes the NonStop™ Himalaya architecture, a highly scalable and fault-tolerant architecture widely used to support real-time transactions. The NonStop Kernel operating system includes distributed systems management, database management, and transaction services management systems, all delivering industry-standard open middleware services and functionality. As a result, clients are able to integrate a wider variety of existing products into their open functionality.
- Support of message protocols such as TCP/IP
- Includes Interface engine supporting HL7, x12 and other standards
- Compaq's SQL/MP relational database
- Compaq NonStop Himalaya S74,000 and S7400 servers, offering scalability from two to more than 4,800 processors.
- Workstations operate in client/server mode. Application code runs on each workstation. Information is presented in Windows-based format but can also operate in a "Web browser" mode. Hardware: 333MHz or higher, 64MB RAM, 100 MB Hard Disk space, SVGA 800x600 display, operating system: Windows 98 or Windows 2000 Professional or NT Workstation 4.0 or newer.
- Optional: Wireless handheld devices (Symbol Technologies/Windows CE devices (320 x 240 screen resolution) with integrated bar code reader. Uses RF (radio frequency) using IEEE 802.11 B wireless standard. Devices continually poll the server so information is current, and run browser software.
- First DataBank National Drug Database File (NDDF): Compendium for medication ordering and pharmacy workflows.
- CA-DB Expert (from Computer Associates) rules engine
- Systems used in providing internal technical access to the Compaq NonStop Himalaya system:
  - OutsideView (from Crystal Point): client browser connection to the system.
  - Prognosis (from Integrated Research Pty, Ltd): provides a comprehensive approach to NonStop Himalaya system management, including integrated data collection, display architecture, and a performance database.

## **McKessonHBOC, Inc.**

One Post Street  
San Francisco, CA 94104-5296  
415-983-8300  
<http://www.mckhboc.com>

### **Company History**

McKessonHBOC Automated Healthcare, a business unit of McKesson HBOC, Inc., has completed a series of acquisitions since 1996, when McKesson acquired Automated Healthcare, a company providing automation products and services for pharmacy and nursing departments. In 1999, McKesson acquired HBOC, a health care information systems company, to form McKessonHBOC. BakerAPS, a provider of pharmacy automation for the retail pharmacy market, was also acquired that year. A recent acquisition was an enterprise-wide pharmacy information system company called Health Care Systems, Inc. (in late 2000).

### **Product Breadth**

McKessonHBOC provides supply, automation, and information technologies that support Internet access, clinical management via point-of-care computing, document imaging, networking, and data integration.

### **Vendor services offered**

- Implementation assistance
- Implementation guide
- Personnel onsite
- Training onsite
- Training manuals
- Software issues and enhancements tracking
- Web-enabled (some products)
- 24/7 emergency support
- Data loading assistance (some products)

### **High-level technical architecture that would be employed for a 300-bed community hospital:**

- Open architecture
- Multiple relational databases including SQL Server, Oracle, etc.
- Multiple Server and hardware platforms including Compaq, Dell, DG, IBM, DEC, HP, etc.
- Wireless handheld devices (Symbol Technologies) with integrated bar code reader. Uses RF (radio frequency) using IEEE 802.11 wireless standard. Devices continually poll the server so information is current.
- Products support HL7 interface formats
- First Data Bank drug knowledge base
- Connect Tech division of McKesson HBOC provides RF network and other hardware configuration services

## McKessonHBOC, Inc.

Product Name	Description
Connect-Rx™	Interface engine that allows integration of medication management systems and data, and real-time communication between systems
Horizon <sup>WP</sup> ™ Care Record	Longitudinal database that uses a common clinical communications architecture
Horizon <sup>WP</sup> ™ Alerts	Rules-based clinical expert system that monitors information and provides notification to the appropriate caregiver
InterQual Products	Clinical decision-support criteria for assessing the appropriateness of interventions
Pathways Care Manager™	A multidisciplinary physician order entry and point-of-care clinical information system that utilizes real-time, bar coded medication administration checking
Pathways Meds Manager™	Pharmacy information system that can be integrated with the longitudinal patient record, electronic order entry, as well as other vendor applications
ROBOT-Rx™	<ul style="list-style-type: none"> <li>■ A centralized medication management system that automates the storage, dispensing, returning, restocking, and crediting of bar coded unit-dose medications</li> <li>■ Responds to electronic drug orders that have been verified in the pharmacy information system</li> <li>■ Can be integrated with automated medication cabinets</li> </ul>
AcuDose-Rx™	A decentralized, automated medication dispensing system that stores, dispenses, and tracks medications
Admin-Rx™	<ul style="list-style-type: none"> <li>■ A medication administration system that uses bar code technology provided through handheld or PC-based technologies</li> <li>■ Can be provided on a standalone or integrated basis and ensures the “five rights” of the medication use practice at the patient’s bedside</li> </ul>

## McKessonHBOC, Inc. — Implementation Steps

Module (Product Name)	Increment	Months to Implement	Relative Difficulty*	Relative Cost**
Pathways Care Manager and Pathways Meds Manager	N/A	12-18	H	4
ROBOT-Rx and Admin-Rx	N/A	6-12	M	4
AcuDose-Rx	N/A	6	L	3

\*Relative difficulty: Low (L), Moderate (M), High (H)

\*\*Relative cost: 1 (lowest) to 5 (highest)

## **MEDITECH, Inc.**

Meditech Circle  
Westwood, MA 02090  
781-821-3000  
<http://www.meditech.com>

### **Company History**

Medical Information Technology, Inc. (MEDITECH) is a software and service company founded in 1969. MEDITECH began to develop healthcare information systems in 1975, starting with financials and patient care modules. In 1988, it released a precursor to the computerized patient record; in 1998, it introduced client/server-based products. The company is privately held.

### **Product Breadth**

The company's software products encompass patient management functions and clinical support for imaging, laboratory, microbiology, pharmacy, blood bank, and pathology.

<b>MEDITECH, Inc.</b>	
<b>Product Name</b>	<b>Description</b>
Pharmacy System	Order processing, lab interface, alerts and checks, user-defined order rules
Enterprise Medical Record	Single-source viewing of patient data fed by other clinical applications in real time
Patient Care Systems	Clinical documentation system using handheld and bar coding technology
Imaging and Therapeutic Services	Automation of ancillary services (e.g., radiology, "therapies")
Laboratory	Laboratory system than can provide lab information and alerts directly to pharmacy system
Microbiology	Can generate a drug sensitivity report directly to pharmacy system
Order entry system	Under development

<b>MEDITECH, Inc. — Implementation Steps</b>				
<b>Module (Product Name)</b>	<b>Increment</b>	<b>Months to Implement</b>	<b>Relative Difficulty*</b>	<b>Relative Cost**</b>
Pharmacy and Patient Care	1	10	M	3
Laboratory	2	8	M	3

\*Relative difficulty: Low (L), Moderate (M), High (H)  
\*\*Relative cost: 1 (lowest) to 5 (highest)



### **Vendor services offered**

- Implementation assistance
- Implementation guide
- Personnel onsite
- Training onsite
- Training manuals
- Software issues and enhancements tracking
- Web-enabled
- 24/7 emergency support
- Data loading assistance

### **High-level technical architecture that would be employed for a 300-bed community hospital:**

MEDITECH offers both two-tier and three-tier client/server architectures.

- The two-tier client/server model is designed for health care organizations operating local area networks. This model distributes an organization's processing between Windows 95/98/NT Workstation clients that run applications and execute functions and Windows NT-based server computers which store data and programs.
- The three-tier client/server model, in contrast, is designed for health care enterprises that operate wide area networks (WANs). This model features Windows 95/98/NT Workstation clients and two tiers of Windows NT-based file servers. In this model, thin client computers display information to users and perform some limited processing. The server computers execute applications, as well as store data and programs.
- The client/server architecture uses Microsoft's Windows NT operating system, widely available computer hardware, and industry-standard network protocols. This is an open-technology platform.

## **Pyxis Corporation**

3750 Torrey View Court  
San Diego, CA 92130  
800-367-9947  
<http://www.pyxis.com>

### **Company History**

Pyxis Corporation, a subsidiary of Cardinal Health, Inc., was established in 1987. The company is a provider of automated medication and supply dispensing systems to hospitals and other health care facilities.

### **Product Breadth**

The company's products focus on medication access, administration, delivery, documentation, and replenishment.

<b>Pyxis Corporation</b>	
<b>Product Name</b>	<b>Description</b>
Pyxis Connect™	<ul style="list-style-type: none"> <li>■ Order management or order management imaging system that utilizes scanning technology and electronic “physician order image transfer” to the pharmacy or patient care areas</li> <li>■ The system functions as a standalone and is interfaced to a pharmacy information system</li> </ul>
MedStation SN®	<ul style="list-style-type: none"> <li>■ A medication automation system, combining controlled access (cabinets with “secure pocket” technology) and profiling capabilities via an interface to the pharmacy information system</li> <li>■ Utilizes a touch-screen application and a bio-metric (finger print access) security system</li> </ul>
PyxisVeri 5™ & PyxisMAR™	<ul style="list-style-type: none"> <li>■ PyxisVeri 5™ utilizes wireless and bar code technology to support and verify medication administration and care delivery</li> <li>■ Captures medication administration information and updates PyxisMAR™ or the facility’s electronic record</li> </ul>
Pyxis PatientStation™	<ul style="list-style-type: none"> <li>■ A workstation positioned at the patient’s bedside that supports various clinical and patient-directed applications</li> </ul>
Homerus™	<ul style="list-style-type: none"> <li>■ An integrated, centralized pharmacy automated dispensing system</li> <li>■ Combines a unit-dose bar code packaging system with an automated medication storage and retrieval system, automating the filling of patient cassettes and Pyxis medication station replenishment</li> </ul>
CUBIE™	<ul style="list-style-type: none"> <li>■ Computerized unit-based inventory exchange</li> <li>■ “Pockets” are filled with medication</li> <li>■ Pocket technology allows access to only a single medication in the medication cabinet during the removal process (versus the entire drawer)</li> <li>■ The pocket also contains a memory chip which “knows” the contents of the individual CUBIE</li> </ul>

<b>Pyxis Corporation — Implementation Steps</b>				
<b>Module (Product Name)</b>	<b>Increment</b>	<b>Months to Implement</b>	<b>Relative Difficulty*</b>	<b>Relative Cost**</b>
MedStation SN	N/A	3-4	L	2
PyxisConnect	N/A	1	L	1
PyxisVeri5/PyxisMAR	N/A	3	M	3

\*Relative difficulty: Low (L), Moderate (M), High (H)

\*\*Relative cost: 1 (lowest) to 5 (highest)

### **Vendor services offered**

- Implementation assistance
- Implementation guide
- Personnel onsite
- Training onsite
- Training manuals
- Software issues and enhancements tracking
- Web-enabled
- 24/7 emergency support
- Data loading assistance

### **High-level technical architecture that would be employed for a 300-bed community hospital:**

- Windows NT-based systems
- Standard LAN/WAN communication
- Standard RF Communication for Veri5/PatientStation products

## Appendix C: Glossary of Terms

**Application** — A software program designed to perform a specific task or group of tasks (e.g., CPOE, pharmacy information systems).

**Architecture** — A structure of all or part of a computer system. Also covers the design of system software, such as the operating system. It also refers to the combination of hardware and basic software that links machines on a computer network.

**Batch** — Pertains to a system or mode of operation in which inputs are collected and processed all at one time, rather than being processed as they arrive, i.e., in real time.

**Best-of-breed** — A term describing the best product of its type. Organizations often purchase software from different vendors in order to obtain the best-of-breed for each application area (e.g., lab and radiology departments purchase products from different vendors).

**Client server** — An architecture in which the client (personal computer or workstation) is the requesting machine and the server is the supplying machine, both of which are connected via a local area network (LAN) or wide area network (WAN).

**Database** — A means of storing organized data. A relational database links files together and allow users to access and reorganize data.

**Device independence** — Describes an application that is not device-specific. Instead, the hardware operating system and its device drivers (commonly a software program that

controls or regulates a hardware device like a printer) “figure out” how to run the application.

**Graphical user interface (GUI)** — Allows users to interact with their computer via icons and a pointer (“point and click”) or lists that drop down under organized headings instead of typing in text at a command line.

**Interface** — The interaction or communication between different entities (i.e., the connection between two or more devices with different functions that allows them to communicate with each other).

**Legacy** — Describes any feature that is based upon older technology. Legacy systems can be maintained in traditional languages as new systems using newer languages and tools are developed for a specific client/server environment.

**Local Area Network (LAN)** — A group of two or more computers in a relatively limited area, connected by cable and using an operating system and application software that enables sharing of hard disks, printers, other peripherals, and files.

**Mainframe** — A large, multi-user computer made for high-volume, processor-intensive computing. A mainframe can usually execute many programs simultaneously at a high speed.

**Operating systems/network operating systems** — Software that controls the execution of programs that run the computer system, i.e., software that allows the user and what-

ever application programs are installed to communicate with the computer hardware. Single-user operating systems are used in clients; multi-user network operating systems are used in servers.

The operating system sets the standard for programs that run under it. The choice of operating system, combined with the hardware platform, determines which ready-made applications can be adopted.

**Plug and play** — A computer specification that refers to hardware and software that require a minimum of effort to install.

**Real time** — Refers to an operating mode under which data are received, processed, and made capable of being acted upon immediately (in contrast to batch).

**Server** — A computer or software package that provides information, files, Web pages, and other services to users connected to it by a network or the Internet. A server can be dedicated to a single function or have a number of server applications running on it for an entire organization.

## Appendix D: Notes

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