

ASHP Guidelines on Pharmacy Planning for Implementation of Computerized Provider-Order-Entry Systems in Hospitals and Health Systems

Purpose and Scope

The purpose of these guidelines is to provide guidance to pharmacists in hospitals and health systems on planning for, implementing, and enhancing safe computerized provider-order-entry (CPOE) systems. To date, most CPOE guidelines have concentrated on the functionality required of a CPOE system, despite the fact that most CPOE system implementations occur using commercial systems whose functionality is largely pre-determined. These guidelines are intended to help pharmacy directors, managers, informaticists, and project managers successfully engage in this type of CPOE system implementation. CPOE is commonly part of a larger health information technology (IT) plan or system implementation. Though many health care technologies impact patient care and pharmacy practice, this guideline will focus on CPOE only. This document is the first of a planned series of ASHP guidelines on CPOE and related technologies and addresses the planning phase of a health-system CPOE implementation, primarily focusing on acute care and associated ambulatory care clinics. The guideline will focus on using CPOE in the medication-use process, though it is important to realize that CPOE includes all orders for patient care (laboratory, nursing, respiratory, and others). Topics covered in these guidelines include

- Developing an interdisciplinary planning and implementation team,
- Defining the vision, goals, and objectives of the CPOE system,
- Establishing essential metrics to measure the success of CPOE system implementation,
- Understanding current and future workflow in order to reengineer the medication-use process as part of CPOE system implementation,
- Planning for scope and depth of clinical decision support (CDS),
- Determining the functionality that ensures the safety of the CPOE system, and
- Educating and training health care providers to use the CPOE system.

Terms used in these guidelines are defined in the appended glossary. The recommendations presented in these guidelines can be used for strategic planning with the organization's decision-makers, drafting contract provisions, prospectively comparing CPOE systems, and creating an implementation plan. These guidelines should be used in conjunction with other literature on the topic and information from prospective or selected CPOE vendors. Pharmacists should exercise professional judgment in assessing their health system's needs regarding CPOE systems and in adapting these guidelines to meet those needs.

CPOE and the Electronic Health Record

In its 1999 report *To Err is Human*,¹ the Institute of Medicine (IOM) shocked the nation with its estimate of deaths due to medical errors. Two large studies, one conducted in New York^{2,3} and the other in Utah and Colorado,⁴ revealed adverse events occurring in 2.9% and 3.7% of hospitalizations, respectively. Over half of these adverse events were judged to be preventable. Based on these studies, IOM estimated that 44,000–98,000 Americans die each year due to medical errors in hospitals.¹ Many of these deaths are caused by medication errors or preventable adverse drug events (ADEs).^{5,6}

When it was recognized that errors resulting in preventable ADEs involved a wide range of drug classes and most commonly occurred at the prescribing stage,⁷ interest in CPOE systems grew. In a second report, *Crossing the Quality Chasm: A New Health System for the 21st Century*,⁸ the IOM called for IT, including CPOE, to take a central role in the redesign of the health care system to improve quality, increase efficiency, and reduce errors. In addition to IOM, organizations such as the Leapfrog Group and the National Quality Forum have pushed for hospitals to adopt CPOE.^{9,10} The American Recovery and Reinvestment Act of 2009 (Recovery Act) authorizes the Centers for Medicare and Medicaid Services (CMS) to provide reimbursement incentives for eligible professionals and hospitals who are successful in becoming “meaningful users” of certified electronic health record (EHR) technology. This law will likely increase the adoption of CPOE in hospitals and health systems.¹¹

CPOE has the potential to affect the ordering of all medications, laboratory tests, medical imaging, nursing orders, and more. Even a basic CPOE system can eliminate illegible and incomplete orders and facilitate efficient order processing through instantaneous transmission of orders to hospital departments such as pharmacy and laboratory. Additionally, CPOE integrated with a pharmacy information system and the electronic medication administration record (eMAR) can nearly eliminate transcription errors, resulting in another potential 6% decrease in ADEs.⁷ A homegrown CPOE system has been shown to decrease medication errors by 55–80%.^{12,13} There are many reports of improvements in physician practices and patient outcomes with health IT related to ordering,¹⁴⁻²¹ but in some reports it is difficult to distinguish whether the benefits were due to CPOE, CDS, the EHR, or a combination of all three. The synergy of the three of these will likely lead to the most significant improvements.^{15,16} Although there are many reported benefits to CPOE, there is a growing body of research pointing to new problems introduced by CPOE. These new problems are collectively known as e-iatrogenesis, which is defined as patient harm caused at least in part by the application of health IT.²² Though the systems themselves may contribute to these problems, design and implementation decisions play a role in the avoidance of these new errors.

More recently, attention has focused on the development of an integrated information system to support the coordination and integration of clinical and business processes. The terminology for such information systems is evolving, with *enterprise information system* sometimes used to describe the broader system that integrates clinical and business systems, and *EHR* used to describe the clinical information system, which may include a patient portal or the ability to link to a personal health record (PHR).²³ CPOE must be viewed in the context of the EHR, which would integrate CPOE, CDS, and departmental information systems and make patient-specific clinical information available to providers.

The EHR is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting.²⁴ It contains medical histories, medication histories, laboratory test results, diagnostic images, clinical documentation, progress notes, narrative summaries (such as operative reports or consultations), and other information related to patient encounters. EHRs provide the ability to manipulate, organize, and present data in ways that are clinically meaningful during the care planning, ordering, and care processes and allow broad clinician access to patient-specific clinical information, which is important to clinical quality and patient safety. When fully deployed within a facility through protected networks, the EHR serves as an information source and platform to coordinate patient care and communicate with the health care team. In addition, codified data can be used to trigger effective CDS as well as to provide data for continuous quality improvement.

For CPOE to be most useful it must be deployed as part of an EHR and not as a stand-alone module. CPOE is the process of health care providers entering orders and related information directly into the EHR. It places the provider at the center of patient care, allowing direct access and secure sharing of health information.

The EHR, including electronic clinician (e.g., physician, pharmacist, nurse) documentation with CPOE and CDS, is important to support the complex effort needed to improve hospital care.^{15,16} The integration of CPOE and CDS within an EHR can create a platform upon which to build and improve the delivery of health care today and in the future. Many organizations implement these in a step-wise fashion because of the enormous work effort and the significant workflow changes required. Although there is no single solution that fits every circumstance, the literature offers many examples for others to follow or avoid.^{25–28} Regardless of the vendor, organization size, or other factors that could potentially affect success, there are quite a number of implementation decisions that can increase the likelihood of a clinician-accepted CPOE installation that leads to quality and safety improvements.

Planning for the Transition to CPOE

A successful CPOE implementation starts with a well-organized, realistic plan. In planning for the transition to CPOE, initial tasks include assembling an interdisciplinary planning and implementation team; developing a vision, goals, and objectives for the CPOE system; establishing essential baseline and post-go-live metrics; mapping current physician, pharmacist, and nurse workflows as they relate to the medication-use process; defining the desired medication-

use process; and planning for CDS. Project management and change management skills are vital for the conversion to CPOE. Because the enormous change in workflow will affect every clinician, standard project management and change management tools, such as a formal project charter, will help keep the implementation on track and manage expectations. Establishing a plan for communication is important from day 1.

Assembling an Interdisciplinary Planning and Implementation Team

The transition to CPOE is an immense cultural change that will affect every member of the health care team. No individual or department will be exempt from the impact of CPOE. Support for the project at the executive level is a prerequisite. Medical and administrative leadership/sponsorship are instrumental in the development of a clear vision for CPOE. An interdisciplinary team approach to planning and implementation is essential for a safe, well-designed, user-friendly, and successful CPOE system.

Physicians must be central players in the decision-making process, as prescriber buy-in and acceptance is crucial to CPOE success. Key departments (such as pharmacy, nursing, laboratory, radiology, admissions, dietary, and respiratory therapy) must dedicate resources and be involved in the initial effort, including workflow/process analysis and redesign, system analysis, integration between ancillary systems, review of organizational culture, and compliance with regulatory, legal, and reimbursement requirements.

The involvement of pharmacists in the development and implementation of CPOE is essential for several reasons. Pharmacists have the benefit of years of experience with electronic order entry systems. Pharmacists' experience with human factors issues related to the interaction between human and computer is invaluable, even though pharmacy systems may differ from CPOE systems in significant ways. In addition, the medication-order-entry aspect of CPOE systems leads to the most significant increase in patient safety and is likely the most complex part of the system.^{21,29–32} The initial decision to purchase a completely integrated CPOE system or develop one that can interface with existing electronic systems (e.g., the pharmacy department's information system) is an important one that would benefit from the pharmacist's perspective. Although the number of successful implementations is increasing on a yearly basis,³³ the complexity of the systems should not be underestimated.

Collaboration among health care staff and the IT department is critical to the selection, implementation, and maintenance of CPOE systems. Although a CPOE system cannot be developed and implemented without IT expertise, the CPOE system is intended to serve the best interests of patients and clinicians. Clinicians and IT staff do not always talk the same language, and differences of opinion are not uncommon. Though difficult at times, these groups must work together for success. IT understands the technical aspects, but physicians, nurses, and pharmacists are best suited to determine how the CPOE system can be implemented to best serve the interests of patients and clinicians.

Recommendations for Team Structure. The organization should carefully consider the structure of the interdisciplin-

any implementation team, which should include physicians, nurses, pharmacists, IT staff, the chief medical information officer, and staff from all ancillary departments (e.g., laboratory services, respiratory therapy). In addition to front-line practitioners, patient safety and quality improvement staff can help immensely with some of the workflow and design decisions. CPOE systems by definition require ownership by the medical staff. Therefore, prescribers (mainly physicians) must be actively solicited for system requirements and be involved in key decisions. CPOE system design, including the content, the user interface, and the flow of CDS, will be influenced by the vendor's product, but acceptance will ultimately reside with the medical staff.

The team structure for implementing CPOE must take into account the interests and expertise of the following types of individuals:

- *Clinical content experts.* Physicians, pharmacists, mid-level providers, nurses, and practitioners of other disciplines who have clinical knowledge and workflow experience that can help shape the CPOE system to be most useful in the local environment.
- *Medical record content experts.* Health care information management representatives who oversee the legal medical record.
- *Technical experts.* Typically, IT professionals who understand the capabilities of the system, write or configure the software, and test and troubleshoot problems.
- *Front-line users.* Physicians, nurses, pharmacists, and others who care for patients on a regular basis and who will understand the positive and negative implications of each proposal regarding CPOE. CPOE's effects on nurses cannot be overstated. The workflow of incoming information completely changes with the implementation of CPOE. The unit secretary will no longer be the gatekeeper and notifier of new orders. The development of an electronic means to notify nurses of new orders must be considered and incorporated into the nursing workflow to enhance patient care.
- *Project managers.* Individuals responsible for overseeing the completion of project tasks and managing timelines and resources. There may be both a facility project manager and a project manager for the vendor or outside contractor.
- *Workflow analysts.* Team members responsible for analyzing the workflow and processes of patient care, from admission through the entire hospitalization (including transfers, surgeries, and procedures) to discharge.
- *Project sponsors.* Clinician champions and organization leaders who can, with frequent reports from the CPOE team, help overcome the many real and imagined barriers to the CPOE transition and keep the implementation on track.
- *Others.* Ancillary staff whose roles or responsibilities may change with the implementation of CPOE.

Representatives from each of these areas of expertise should work together regularly, in a variety of committees and work group formats. The team should report to a key organizational committee (e.g., the pharmacy and therapeutics [P&T] committee) as well as medical staff or other governance-related bodies. Communication with many formal committees is

important as early as possible. The hospital should consider the merits of compensation for time spent away from clinical duties. The health system's existing committee structure may be utilized as oversight authority for CPOE initiatives before, during, and after the system goes live. However, it is highly recommended to create small work groups consisting of physicians, administrators, pharmacists, nurses, and IT personnel to make and approve design decisions and form specific task groups as needed when policy or process issues arise. Quick and timely action will be required during the implementation phase to keep the project moving forward on schedule and in an organized and cohesive manner. This interdisciplinary group should refer matters of policy to existing policy-making committees (e.g., P&T committee, medication safety committee, executive committee, practice guidelines committee, leadership council). The interdisciplinary CPOE committee is not a policymaking committee, but rather a tool to provide structure to existing policies. Some organizations may find it necessary to keep this new formal committee for ongoing oversight of clinical information systems and CDS decision-making.

Pharmacists are needed to provide oversight of medication-use process development. Pharmacist involvement should begin in the initial CPOE planning stages and continue throughout all phases of CPOE development and optimization. The pharmacists that serve on the interdisciplinary team would ideally be relieved of clinical duties to the extent possible in order to commit much of their time to the complex project. Those pharmacists could remain in the pharmacy or be physically relocated to whatever space the interdisciplinary team is allocated. Any pharmacist chosen to serve on the team should be

- A team player,
- Well-respected within and outside the pharmacy department,
- A good communicator,
- Knowledgeable about all facets of the medication-use system, especially the thought process prescribers use to determine a treatment or treatment plan,
- Well-versed in the regulatory and legal requirements of medication management,
- Current on patient safety initiatives and issues, both external and internal to the health system,
- Detail-oriented, with sharp analytical skills,
- Open to new ideas,
- Very interested in informatics,
- Capable of handling stressful situations and limited time lines, and
- Able to differentiate the requirements of an ordering system from those of a dispensing system and translate those requirements for others.

Outside Consultants. External consultants may be used in a variety of roles, including evaluation and vendor selection as well as project management and post-implementation assessments. Use of outside consultants may be warranted if there are insufficient resources, lack of on-site knowledge of the vendor's application, or a desire for a quicker implementation timeline. Consultants add a unique dimension to the team structure in that they have experienced how other hospitals have solved similar problems, can offer a variety of solutions based on their experience

from other facilities, and have a network of colleagues they can contact for advice. Having a consultant engaged early in the process can provide continuity to the development and implementation processes.

External consultants should work in conjunction with permanent members of the implementation team. It is important that the permanent members of the team know and understand how the system was designed, how its components fit together, and how each item was built by the consultants. Changes in one part of the system may have intended and unintended downstream effects. Modifications to the system are inevitable, and the on-site team must have the knowledge to understand and execute the necessary future changes. It is detrimental to have this knowledge leave with the consultant when the contract expires. Formal documentation and knowledge transfer meetings should be part of the consultant deliverables.

Allocating Resources. The resources required to manage the transition to a CPOE system will vary, based on a number of factors: the size and complexity of the institution, whether it is an academic or a community setting, types of patients served, current IT infrastructure, the scope of the CPOE project, commitment of implementation project team members, degree of system integration, and other circumstances. There are no general rules about the time, money, or number of employees required for such a transition. Vendors may perform an assessment to help determine the resources that will be required based on the institution's circumstances.

The resources needed should be identified and approved before the project begins, and monitoring of ongoing resource needs and allocation will be necessary. Planning often focuses on capital expenses, underestimating the personnel required to build, test, maintain, improve, and train staff on the use of the system.²⁹ Having these resources in place is critical to the success of an implementation. During planning and implementation, resource needs may vary, based on project activities. Following implementation, order sets and CDS are integral components of managing care, and the ongoing maintenance to keep the care components current and in line with practice requires ongoing resources. In addition, as the complexity of the system increases with enhancements and user requests, resources needed for ongoing management may increase. Understanding these needs before implementation can help in resource planning.

Developing a Vision for the CPOE System

A vision statement helps describe where the organization wants to be after CPOE implementation and helps define decision-making criteria and the framework for metrics. It is imperative that the CPOE vision align tightly with the vision of the organization as a whole. Large-scale projects should include a clear organizational vision, which might be as simple as increasing patient safety or improving provider access to information. Taking the time to develop these criteria will focus the team throughout the design and implementation processes, help the team communicate the rationale for the necessary change that front-line clinicians will have to make, and lay the groundwork for ongoing measurement.

CPOE is a vital component of the institution's overall patient safety and IT development plans. It is important to establish from the beginning that CPOE is a clinical interven-

tion and not an IT implementation. The implementation team should determine whether there are other issues that may influence CPOE implementation, such as new buildings or other system changes (e.g., pharmacy, bar-coding, or eMAR systems). The team should review and attempt to anticipate trends in regulation or best practices (e.g., from CMS, the Joint Commission, the Institute for Safe Medication Practices, or ASHP) and adopt practices from similar sites that have implemented CPOE. Finally, it should be remembered that CPOE is only one element of the hospital's IT infrastructure. Care should be taken to integrate these disparate systems, with the end result of a complete EHR.

Pharmacy involvement in CPOE development and implementation will be related mainly to medication use within the health system. Pharmacists often have experience with entry of medication orders into a computer system. This experience can be used to help providers adapt to the changes that come with CPOE, but pharmacists should be aware of the differences between ordering medications and verifying and dispensing them. Financial goals, hospital infrastructure, integration, and regulatory compliance also play an important role in the development of a vision for CPOE.

Developing a vision for medication orders in a CPOE system can be divided into three main tasks: defining the goals and objectives for the CPOE system, mapping the current and desired medication-use processes, and determining CPOE system performance requirements to reach those goals. An organization's physicians, nurses, pharmacists, other providers, and administrators can team up to prepare this vision. The vision might include describing how products should be named for easy identification or the configuration of special populations of orders. Consideration should also be given to how medication orders relate to other orders, laboratory test results, allergies, and other clinical information.

Defining Goals and Objectives for the CPOE System

Implementing CPOE is an immense cultural change that involves every part of an organization. After an overarching vision for the components of the CPOE system has been established, the implementation team should reach out to all areas of the institution to develop and explain the goals and objectives of the CPOE system. Widespread understanding and acceptance of these goals and objectives will facilitate development and implementation of the CPOE system. The central goals of a CPOE system typically include improving medication safety and the quality of health care processes.

Medication Safety. Improving the safety of the medication-ordering process should always be in the forefront of any design decision, programming modification, or enhancement to CPOE. The analysis of the existing medication-use process (see "Mapping the Current Medication-use Process" below) should identify any safety deficiencies that can be corrected with CPOE, as well as the strengths of the current processes. The addition of safety features to CPOE will be an ongoing endeavor, as acceptance of the system grows and clinicians realize how the system can improve their practices.

CPOE systems need to be monitored for unexpected safety failures. CPOE can introduce previously unknown safety failures through user interaction with the system, programming changes, or poor system design.²⁶ To prevent

the introduction of new medication errors, careful analysis, review, and testing needs to be conducted with initial implementation and subsequent additions, modifications, and enhancements. Constant surveillance for errors and unanticipated outcomes is an ongoing necessity.²⁹ This evaluation can also be used to develop the goals and objectives for implementation.

A major impetus behind CPOE is that the deployment of a well-designed CPOE system with effective CDS can reduce medication errors and ADEs. A systematic review of the effects of CPOE with CDS on medication errors and ADEs supports the successful use of CPOE in health care facilities.¹⁸ Many hospitals will implement CPOE to improve patient care, while focusing less on research that explores its impact. Nevertheless, internal systems for tracking medication errors and ADEs should be continually used to assess the impact of CPOE. CPOE could potentially

- Reduce some forms of ADEs or medication errors,
- Qualitatively change some forms of ADEs or medication errors (e.g., an error of omission may become a wrong-time error), and
- Introduce new types of ADEs or medication errors (e.g., a physician may select the wrong drug or wrong patient from a list appearing on the computer screen or inappropriately select a default dose).

Quality of Health Care Processes. In addition to improving medication safety, the goals of CPOE implementation may include such things as decreasing drug or laboratory costs, reducing the time required for pharmacist medication order review, improving data collection, or increasing communication among health care team members. If efficiencies from the direct entry of medication orders by the physician result in time savings in the pharmacy, the pharmacy department could potentially direct more pharmacist resources to patient interaction or areas such as pharmacotherapy consultation, pharmacokinetics, anticoagulation monitoring, drug regimen review, antibiotic streamlining, or intravenous-to-oral (i.v.-to-p.o.) conversions. Such goals will be different for every organization, but it is important to establish them during the planning phase of the project. The transition to CPOE represents a major paradigm shift for most organizations. The organized, goal-oriented institution will benefit from creating concise, measurable goals and objectives.¹⁹

Establishing Baseline Data

In conjunction with the analysis of the current medication-use process, the interdisciplinary team should develop a clear and complete understanding of the institution's current medication safety data (e.g., medication errors, ADEs) as well as the resources devoted to the manual medication order system.^{34,35} It is important to track data for at least three months in advance of implementation to assemble adequate baseline data. These data can then be compared with data from the CPOE system at designated intervals. Data should be tracked over time to assess the impact of the CPOE on the medication-use process. This information can help identify workflow bottlenecks or discrepancies in the CPOE system, providing opportunities for improvement. Examples of data that may change with the implementation of CPOE and CDS include errors related to known drug allergies, ADEs related

to drug–drug interactions, prescribing errors related to drug dose, and drugs withheld due to contraindications identified via CDS.

Establishing Post-Go-Live Metrics

Implementation metrics can be used to help measure achievement of organizational goals. Comparing baseline and post-go-live measures can identify which areas have improved and which need further review. Metrics are quantitative, measurable parameters, and may include

- Order entry time (e.g., average time it takes a provider to enter an order³⁶),
- Compliance with established evidence-based order sets,
- Number of entered orders,
- Missing doses,
- Pharmacist interventions related to order entry problems,
- Changes to scheduled administration times in the system,
- First dose medication administration turnaround time,
- Assess possible financial indicators of success,
- Frequency of provider contact (e.g., pages for questions or errors on order entry), and
- Documented medication errors.

When reporting these data, the hospital should be careful not to overstate the impact of the CPOE system on patient outcomes. The measures listed above are process measures, not outcome measures. For example, although the CPOE system may have flagged a patient allergy and prevented administration of the medication, it is possible that even without the CPOE system the pharmacist or nurse would have identified the allergy and intervened before the drug was administered.

It is important to identify and report new errors or ADEs introduced by the CPOE system.^{22,25,26,31,37–40} The hospital should actively engage clinicians at all levels in open dialogue and reporting of such issues. These reports should be used to make rapid changes in the design of the system in the spirit of continuous quality improvement.

Describing the Current Medication-Use Process And System Design

To ensure that the integrity, safety, and efficiency of the entire current medication process are maintained, if not enhanced, it is important to perform a complete analysis of the current medication-use process. This analysis should include the interdisciplinary workflows associated with medication use for multiple types of medications. The output can be represented in a variety of ways, including flow charts, narrative scenarios, analyzed issue/problem reports, and comparisons of current practices to known best practices.

The analysis of the current medication-use process should consider a variety of medication order types, based on frequency of use or potential impact on patient safety, in all different process settings (e.g., acute care, critical care, emergency department), procedural areas (e.g., diagnostic imaging), and patient populations (e.g., pediatric, geriatric, adult). The project team should consider a representa-

tive group of orders that includes the basic types of orders prescribers typically write. How orders are currently entered into the system may not necessarily be intuitive to a physician. Most importantly, the project team should consider how the prescriber currently orders medications and what would make the most sense to the prescriber when ordering electronically. CPOE systems should be designed from the prescribers' perspective, with an eye on how orders flow over the course of their existence, to encompass all facets of medication use, ensuring the process is complete from medication reconciliation through ordering, renewing, and discontinuing. Complex medication orders and/or protocols may need special attention because of current technology limitations or workflow differences. The types of medication orders that should be reviewed and included in the design, as well as the processes across which they should be considered, are listed in Figure 1.

The description of the current medication-use process should be developed from a number of sources: observation, paper order sets, discussion with clinicians, and the knowledge of those who have worked on the organization's previous process-improvement efforts. This process is an opportunity to engage staff pharmacists who service various areas of the organization. Pharmacists often have a broad view of the medication-use process, seeing it from end to end, both receiving orders from physicians and helping address complex administration scheduling issues. The project team should strive to understand the current state of the medication-use process in terms of the components listed in Table 1, which also lists the form best used to represent the component.

Developing the Future Medication-Use Process and System Design

Once the current state of the medication-use process is well understood, one or more instances of the future state (depending on the plan for phasing in the CPOE system) can be designed. This future state should be designed to meet or exceed the current levels of service and other important designated metrics and priorities (e.g. patient safety, first-dose delivery time) and address any desired improvements.

The CPOE system should be designed to support the hospital's ideal medication-use process as much as is possible. The system should be configured to support clinicians and promote improved patient care processes, rather than compromising these processes to accommodate system functionality. It will likely be necessary (and desirable) to change many of the key work processes to ensure that benefits (such as improved medication safety) are achieved. A description of the ideal medication-use process is beyond the scope of these guidelines, but key steps in a typical medication-use process are outlined in Figure 2.

A successful CPOE design is a combination of process, information systems, and supporting technologies that work together to allow the desired improvements to occur. Figures 3-6 list some of the process and technology enhancements that should be considered for incorporation into the new process/technology/system design.

The desired benefits of the CPOE implementation should be clearly identified, and the process and system design should make those benefits possible. The design should include the practices, work processes, and techno-

Figure 1. Types of medication orders and processes that should be reviewed and included in CPOE design.

Medication Order Types	
<ul style="list-style-type: none"> Oral solids Oral liquids Topicals High-risk medications (e.g., anticoagulants, heparin, insulin, or potassium chloride) Compounded medications, such as triple mix or acetazolamide suspension (e.g., oral swish-and swallow or dermatological preparations made in the pharmacy) Combination products (e.g., hydrocodone-acetaminophen, multi-drug inhalers) Combination doses Respiratory therapy Total parenteral nutrition I.V. medications <ul style="list-style-type: none"> Piggy-back i.v.'s Continuous infusion medications and titrations Flushes 	<ul style="list-style-type: none"> Medical staff protocols that include medications Automated dispensing device overrides Irrigations Immunizations Patient-controlled analgesia, including epidural analgesia Sliding scale insulin and heparin Chemotherapy standard and non-standard protocols Conditional orders Hemodialysis, peritoneal dialysis, and continuous renal replacement solutions Investigational medications Herbal medications Ophthalmic or otic medications Injectable medications (e.g., i.v. push, i.m.) Medications used in operative and procedural areas Linked or interdependent orders Medications used for diagnostic imaging
Medication Order Processes	
<ul style="list-style-type: none"> Ordering (physician or other clinician) Electronic signature, signing of verbal orders Medication reconciliation Preparation and labeling Medication order review Dispensing and distribution (including interface to automated dispensing devices) Administration and documentation 	<ul style="list-style-type: none"> Medication schedule changes Holding orders Code medications On-call to operating room or procedures Future orders Negative orders (e.g., do not give aspirin) Charging Transfer orders

Table 1.

Components of the Medication-use Process and Formats Best Suited to Representing Them

Component	Representation
Activities performed	Process flow chart
Strengths and weaknesses of the current process	Text/table
The person(s) performing the activities	Text
The information needed in order to perform the activity	Text
The tools and systems used to perform the activity	Flow chart
The outputs of the activity and where they are sent/recorded	Text
The time/effort used to perform the activities'	Text
The barriers, constraints, reductions in efficiency, and limitations on the activity	Text

logical components in an integrated fashion. General process design principles are listed in Figure 7.

The future state design should be an interdisciplinary effort that considers the entire medication-use process, even though parts of the process may not change or may not change much with CPOE implementation. It is important to maintain the continuity and integrity of the process by making sure that the design of the component activities is compatible and completely accounts for manual or previously automated processes.

The draft future state design is typically done with a small interdisciplinary group of clinicians (the “core team”) who understand the current process and the capabilities and limitations of the CPOE system. This group should consist of clinicians who order (physicians, nurse practitioners, and pharmacists), dispense (pharmacists and pharmacy technicians), and administer (nurses and physicians) medications. This core team should have dedicated time for the project, or at least be relieved of their regular staff schedules for the time spent working on the project. The charge of this group is to weave into the system design the following factors:

- Existing work processes and systems,
- Best practices,
- New systems, with consideration for their capabilities and limitations,
- Physical limitations (e.g., space, facility issues, staffing limitations),
- Political issues (e.g., organizational priorities, limited physician cooperation or interest in CPOE),
- Desired benefits and performance improvements, and
- Compliance with regulatory, legal, and reimbursement requirements.

This redesign typically starts with a high-level process flow diagram that describes the activities performed by each member in the medication-use process, coupled with demonstrations of the system capabilities and flow. Through successive iterations, the workflow and system design is brought into increasing levels of detail and expanded to address the factors listed above.³⁴ Once the core team is satisfied with the design, practicing clinicians can be brought in to validate and improve the design. The clinicians involved in these process redesign sessions should be experienced and practicing clinicians who understand the current process and will likely find the potential issues with the new processes.

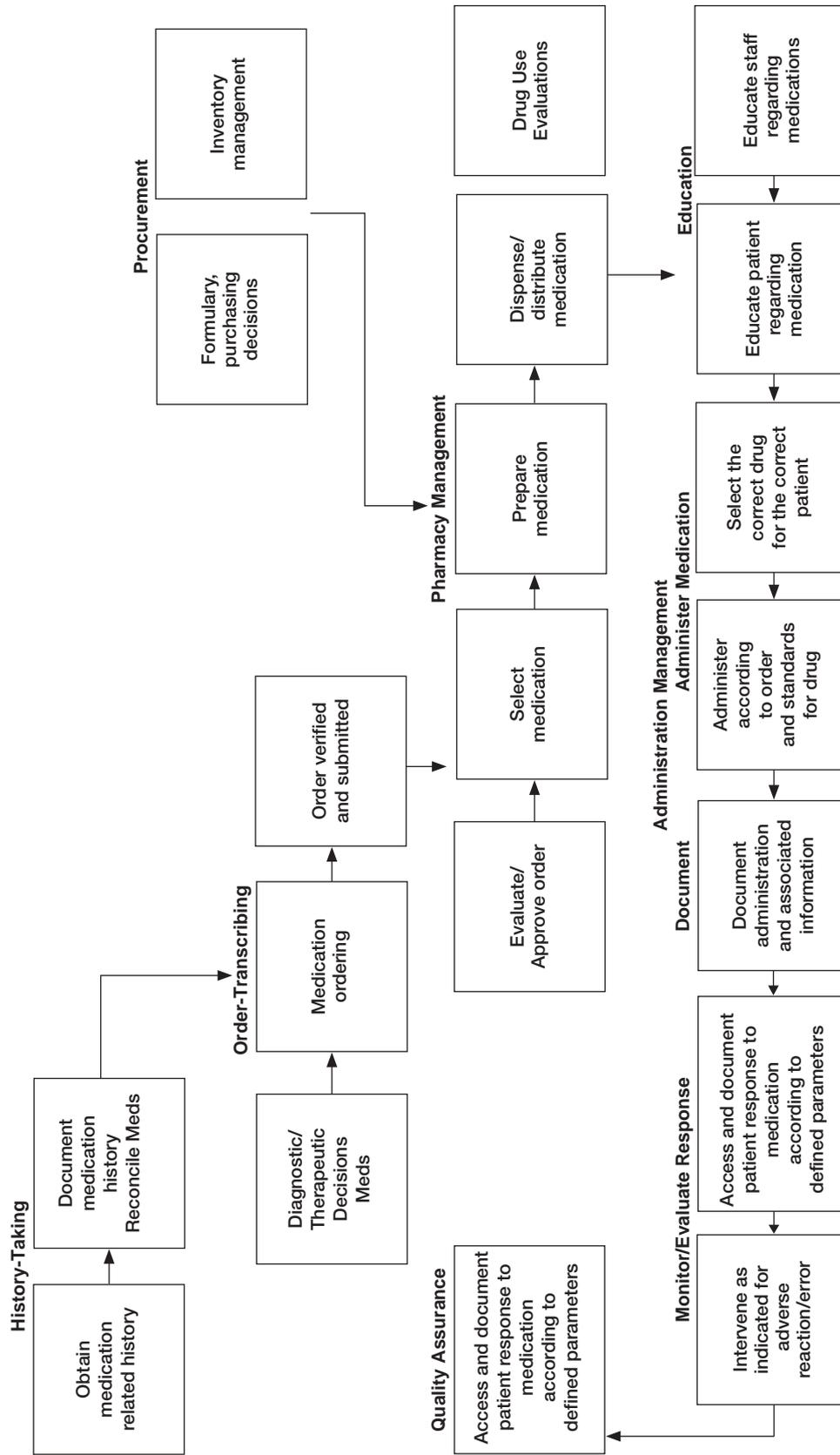
These process redesign sessions should be as practically focused as possible and should demonstrate prototypes of orders and output from the system. They should provide a forum to discuss what to do and how it will be done. The redesign will likely take at least three or four sessions to cover the necessary detail of all the affected processes. The information gathered from these sessions can then be used to complete the process and system design and build the policy and procedure and training documents.

Failure Mode and Effects Analysis. A safety analysis of the future state design should be done prior to implementation to identify unintended or unidentified consequences.⁴¹ Failure mode and effects analysis (FMEA) is a useful tool to prospectively evaluate the potential risks associated with the new process and identify inconsistencies or omissions that may have the unwanted effect of increasing risk to patient safety rather than reducing it.^{41–44}

Other Design Considerations. It should be determined whether there are required elements at provider order entry in order for the pharmacy to verify orders (e.g., patient allergies, weight). Integrated systems start to break down the silos in which physicians, nurses, and pharmacists sometimes practice. There should be one shared field for allergy and weight documentation, so any expected workflow changes need to be discussed prior to implementation. Though it is the right thing to do, this standardization often uncovers workflow issues that were previously hidden in the paper process. The current process for handling allergy conflicts or drug interactions should be examined and it should be determined how users will handle an alert in a critical or time-dependent area, such as the emergency room. It should also be determined whether there is a need for an additional set of elements for order processing (e.g., laboratory or other results).

Medication Use within the Context of CPOE and the EHR. Whether your organization implements CPOE alone or along with other parts of the EHR (such as the eMAR), other parts of the medication-use process will be affected. To meet the long-term goal of a complete EHR, all medication orders should be included in CPOE. Having disparate ordering systems (i.e., manual and electronic systems) causes confusion, creates additional work for health care professionals, and presents risks to patient safety. The hospital

Figure 2. Medication-use process model. Reprinted, with permission, from reference 32. Copyright, VHA, Inc. 2001.



must recognize that CPOE may increase the amount of time the medical staff spends on prescribing medications, at least in the beginning.^{45,46} Therefore, there must be considerable dialogue with the medical staff about their role in the overall

medication-use process. It is important that they understand that CPOE is an effective way for them to communicate their orders and improve the timeliness, accuracy, and safety of patient care and that efficiency should improve over time.

Figure 3. Potential process and technology interventions in order writing and submission to improve medication safety. Reprinted, with permission, from reference 32. Copyright VHA, Inc. 2001.

Ordering: Order Writing and Submission

Process Interventions

Establish standards for abbreviations
 Establish policies that do not accept incomplete or vague orders such as "continue previous medications"
 Establish standard protocols for drug dosing and administration
 Develop standard order sets to include drug order, time associated tests, and associated medicines
 Provide routine staff education on common causes of error
 Educate staff on back-up procedures for system down time
 Establish policies for routine review and updating of current orders
 Monitor the bypass of rules and alerts to complete order
 Do not dispense drug prior to written order or verbal order verification unless critical
 Minimize verbal order use

Technology Interventions

Implement tools to guide the user:
 Order entry (CPOE) with standard order sets and protocols
 Mandatory fields to complete an order
 Rules-based ordering to include dose adjustment, interaction checking, and accompanying orders
 Provide formulary selections
 Provide mobile charting devices to allow for ordering at the point of care
 Adequate back-up procedures for system down
 Updated Mar generated by CPOE or pharmacy system on routine basis (minimum every 24 hours)
 Automated reminders or alerts for changes in patient status
 Automated dispensing units do not dispense drug prior to order verification unless a critical medication

Figure 4. Potential process and technology interventions in medication history-taking and medication reconciliation to improve medication safety. Reprinted, with permission, from reference 32. Copyright VHA, Inc. 2001.

Medication History-Taking and Medication Reconciliation

Process Interventions

Establish procedures for obtaining admission history
 Establish minimum data set to include medications, diagnoses, height, weight, and allergies
 Establish accountability for obtaining minimum data set
 Use standardized templates
 Multi-disciplinary clinical documentation
 Instruct patient/family on need to bring all current medications with them, including over-the-counter medications
 Select and identify "record of truth"
 Establish communication links with primary and extended care providers to support transitions in level of care
 Replace free text with checklists when appropriate
 Establish standard abbreviations for medication recording
 Provide wallet cards or other forms to prompt patients to bring complete home medication information

Technology Interventions

Implement tools to guide the user
 Clinical documentation with templates and checklists
 Prompts for required fields to include minimum data set
 Flags to highlight changes in minimum data set from previous data
 Improve access to patient record through implementation of computer-based patient record/clinical data repository
 Establish communication links with primary and extended care providers to support transitions in level of care
 Provide mobile charting devices to allow for documentation at the point of care
 Structured for computer-based clinical documentation
 Technology adherence to standards

Figure 5. Potential process and technology interventions in pharmacy evaluation of orders to improve medication safety. Reprinted, with permission, from reference 32. Copyright VHA, Inc. 2001.

Pharmacy Evaluation of Orders

Process Interventions

Establish standards for abbreviations
 Establish policies that do not accept incomplete or vague orders such as "continue previous medications"
 Develop standard order sets to include drug order, associated tests and associated medications
 Provide routine staff education on common causes of error
 Do not dispense drug prior to order evaluation unless critical
 Establish procedures for evaluation of orders and when to clarify
 Establish procedures for pharmacy dosing
 Develop procedures for escalating an order that is on hold for clarification

Technology Interventions

Adequate back-up procedures for system downtime
 Minimize system downtime
 Automated reminders or alerts for patient changes in status
 Pharmacy alerts and reminders based on change in lab value, drug-to-drug interaction, dose-checking, drug-to-diagnosis, drug-to-allergy checking
 Targeted alerts that vary by individual receiving them to reduce alert fatigue
 Ability to view online clinical information to include: lab values, clinical documentation and orders
 Interfaces to auto-populate pharmacy system with ADT, laboratory, clinical documentation
 Access to drug knowledge base

Figure 6. Potential process and technology interventions in administering medications to improve medication safety. Reprinted, with permission, from reference 32. Copyright VHA, Inc. 2001. RFID = radio frequency identification.

Administering Medications

Process Interventions

- Standardize medication administration times
- Standardize equipment for IV infusion; minimize number of different kinds of devices
- Provide tools that assist staff in calculating correct rate of infusion
- Stock pre-mixed IV drugs
- Establish standard dose packaging and labeling
- Patients with multiple IV access lines have line clearly marked at distal end
- Distal ports of non-IV tubing incompatible with medication oral syringe
- Standard protocols for the physical assessment prior to administering a specific drug throughout the hospital

Technology Interventions

- MAR with time based schedule
- Electronic MAR
- Automated drug distribution carts at the point of care
- Smart infusion pumps
- Alerts to caregiver to obtain and document clinical information prior to administering a drug
- Bar code/RFID administration systems
- Comprehensive wireless network coverage
- Needleless administration system
- Other medication delivery technologies

Figure 7. General CPOE process design principles.

CPOE Process Design Principles

- Standardization of order entry and management information and workflows across the organization to the degree possible.
- Simplifying processes.
- Creating an effective interdisciplinary, team-based approach (i.e., improving communication).
- Designing mechanisms for reporting and learning from errors.
- Seeking redundancy through use of technology to support clinical decision making.
- Avoiding reliance on memory.
- Using constraints and forcing functions where appropriate.
- Simulating planned and unplanned events for how people interact with each other and technology.
- Planning for failure and designing for recovery.
- Providing access to a core set of integrated clinical information at the time and point of decision-making.

The hospital should provide incentives for prescribers to utilize the system and disincentives for giving verbal orders or continuing to handwrite orders. To facilitate use of the system, prescribers should have access to the CPOE system from multiple venues, including their offices and homes and via wireless computers. If clinicians have the ability to enter orders from multiple locations such as home or office, a defined process should exist to easily reach the prescriber if there is a problem with the order (e.g., non-formulary, lack of availability).

All new orders should be verified by a pharmacist and reviewed by a nurse, and these actions should be documented in the EHR prior to medication administration. The nurse should work directly in the EHR for all clinical documentation, including medication administration. To comply with the “five rights” of medication administration,⁴⁷ a workstation must be available close to the patient’s bedside with ready access to that patient’s relevant information to facilitate resolution of any questions on the medications that arise. Figure 8 lists some design considerations for the workgroup as new workflows are designed for different clinical scenarios.

Computers (both wired and wireless) should be available in sufficient quantities so that no clinician has to wait to use one. It is critical that the technologies used for stationary and mobile computing be matched to the anticipated workflow. It is likely that stationary computers, handheld devices (e.g., personal digital assistants), and tablet and cart-mounted computers will all be needed for some part of medication ordering for various users. If they are not part of an integrated system, the CPOE, eMAR, and pharmacy information systems should be available on the same computer to facilitate switching between systems. Any other technologies that are used by providers (e.g., voice recognition) should not only be on the same computer but ideally available from these devices as well. Users should be able to easily switch between different applications if needed, and clinical data should freely flow between applications so that the pharmacist and other providers have real-time access to the same information.

Planning for CDS

CPOE is an important part of an organization’s plan for improved safety and quality. The addition of CDS to the EHR and CPOE is essential for the prevention of adverse events and improvement in patient outcomes.^{17,20,21} A full discussion of CDS is beyond the scope of this document. ASHP plans to cover the topic in future guidelines. The purpose of this section is to provide an overview of CDS that will allow incorporation of CDS to be addressed in planning.

CDS can be defined as providing the appropriate clinicians with clinical knowledge and/or patient information intelligently filtered and presented at appropriate times to enhance patient care.⁴⁸ CDS has many intervention types, including but not limited to the following⁴⁹:

- Documentation forms/templates (structured guidance, required or restricted fields, checklists),
- Relevant data presentation (optimize decision making by ensuring all pertinent data are considered),
- Order/prescription creation facilitators (pick-lists, pre-completed order sentences and order sets),
- Protocol/pathway support (multistep care plans, link to evidence or protocol, pertinent reference information or institution-specific best practice guidance),

Figure 8. CPOE design considerations.**Design Considerations**

- How do orders post to the MAR, and what is the relationship between the MAR and intake/output flowsheets?
- Are there other documentation flowsheets that are also used or needed (e.g., patient-controlled anesthesia, continuous renal replacement therapy)?
- When do orders need to be approved by pharmacy before a nurse can chart or administer the first dose of the medication?
- Can nursing staff easily tell when the order has been verified by pharmacy?
- Is there a mechanism to have critically needed orders available on the eMAR before pharmacist review?
- What medication information is displayed to the nurse for administration (i.e., both brand and generic names)?
- How are orders sorted on the MAR (e.g., are as-needed orders separated from scheduled orders)?
- Are administration instructions and notes required (e.g., do not administer oral ciprofloxacin with Maalox)? Will they be supplied from the CPOE system or from the pharmacy system?
- Are nondrug items needed on the MAR (e.g., wet to dry dressings)? If so, how will these items be entered (i.e., are these orders that pharmacy must review and approve)? Can some type of treatment administration record be created for these items?
- Is there a chart on removal from an automated dispensing cabinet or are auto-charting functions in use?
- How will the health system develop a bar-coding system for medication administration?
- Override rates of alerts by both pharmacists and providers to better set sensitivities for the warning.
- Order verification times by pharmacists to determine turn-around times for different priorities of medication ordering.
- Compliance to clinical practice guidelines and order sets.
- If integration of the CPOE system is available with automated dispensing devices, then monitoring for overrides would be warranted.
- Monitoring free-text orderables in the system, to better address the provider's needs and provide guidance for appropriate formulary build.
- Does the software provide the ability to designate a medication and document "First Dose Effectiveness"?
- How are enteral nutritional supplements and tube feeding supplements documented, ordered, etc?
- Does the software provide "Query Tools"?
- Will provider, pharmacist, nursing software "Hand Off" IT tools be needed?
- Does the software handle "Look-A-Like, Sound-A-Like" medications and due to this aspect should generate medication nomenclature be utilized exclusively?
- Does the software provide the functionality for "after hours" entry and how will the review be completed if pharmacy service is closed?
- How will MAR/eMAR handle multi-component medication orders?
- How will MAR/eMAR process fractional doses of medication package forms?
- How will reporting needs be developed and integrated into the system for users? When?
- How are co-signatures or verbal order sign-offs obtained?

- Alerts and reminders (drug–drug interactions, therapeutic duplication, drug–disease, allergy alerts, and others), and
- Automated ADE detection based on patient symptoms, labs, diagnostic results, and patient notes.

Because CDS has such a broad definition, the line between CDS and CPOE is not always clear. Basic forms of CDS, such as fully defined order sentences and order sets, are an important aspect of CPOE and can decrease errors while enhancing clinician acceptance of the system.^{27,28} This type of basic CDS encourages clinicians to make proper choices initially rather than alerting them to potentially problematic choices after the fact and is an essential part of any CPOE implementation.

An organization must recognize that to realize the benefits of CDS, the CPOE system must be accepted by clinicians and used effectively. Poor design or too many alerts could lead to system rejection or, even worse, unanticipated outcomes such as increased errors or adverse events.^{25,26,50–53}

Some CDS, including checks for allergies, drug–drug interactions, drug duplications, and dose ranges, are typically delivered via an interruptive alert to the user or displayed as a passive warning on an order entry screen. Such CDS should be considered before CPOE implementation, but designers should keep in mind that a high number of interruptive alerts may cause clinicians to ignore alerts alto-

gether and may even threaten clinician acceptance of CPOE. The way alerts are prioritized and presented to the user may be as important as which alerts are presented. Alerts for very serious clinical situations may be ignored when lost in a sea of less important ones.⁵⁴ Some vendor systems allow clients to change severity levels or even disable some alerts in an effort to bring alert interruptions to a better signal-to-noise ratio and thus decrease the potential for alert fatigue, particularly for physician recipients.^{50–52} Ideally, there needs to be an alternative mechanism to provide CDS feedback to prescribers that is not intrusive but still allows the prescriber to know that there may be issues with an order. If ignored, these alerts can be acted upon by the pharmacist.

The strategy for prioritization of CDS should be defined as early as possible, and pharmacists should take a leading role in all medication-related CDS. It is likely that organizations will be eager to implement CDS along with CPOE. Pharmacists should ensure that the CPOE system is implemented with basic CDS, such as order sets and sentences, while using appropriate caution when implementing alerts.²⁷ Although vendor systems are continuously improving and may allow tiering of alerts, there is typically a significant amount of work necessary to vet any changes and carry out the technical work involved in the customization. The combination of pharmacists' clinical knowledge of drugs and their experience with the interruptive alerts that have been present in pharmacy information systems for

years provide pharmacists with a unique understanding of the many implications of implementing medication-related CDS. Pharmacists should work with medical leadership, either through the P&T, informatics, or another interdisciplinary committee, to decide how and when medication-related CDS will be added to CPOE. Pharmacists are well positioned to formulate local evidence criteria, collect information on medication therapy outcomes, and to bring together institutional health providers for the purpose of setting priorities and targeted outcomes where select IT interventions are made. The design, implementation, and optimization of CDS is an exciting area of opportunity for pharmacists now and in the years to come.

Elements of a Safe CPOE System

Minimum Features and Functions. The implementation group and key stakeholders should consider what features and functions of the CPOE system are desired both now and in the future. Starting with a pilot group of users allows experience with the system to build and permits users to work through some process issues before system usage is widespread. Any pilot should be brief, with plans for a roll-out shortly after addressing the major discoveries. A highly sophisticated system may take so long to develop that interest is lost, or it may be too sophisticated or rigid in its initial application to be well accepted.

An important consideration during CPOE implementation is the determination of which functionalities are required for go-live. CPOE will always be a work in progress, and there will be opportunities for modifications and enhancements. At a minimum, the project team should evaluate all existing manual medication ordering processes, including such complex orders as epidurals, patient-controlled analgesia, weight-based dosing, lab-result-dependent dosing, tapering medication doses, total parenteral nutrition, and chemotherapy, along with critical patient safety functionality driven from known internal or external sentinel events. An agreed-upon list of basic functionality should be established in order to ensure a timely yet successful go-live. If some complex or high-risk medication orders will be left on paper at the initial go-live (e.g., chemotherapy), be sure this is well communicated during training. As well, this principle applies to other identified yet unresolved design topics. The project team will need re-visit these topics for completion in the post-go-live period.

General Features and Functions. The user interface is often a problematic aspect of CPOE. Users have been reported to enter orders for the wrong patient or to select the wrong item (or wrong feature of an order) unintentionally because they did not use selection lists properly or because it is very easy to select the wrong item from a drop-down list.³⁸ The CPOE user interface should incorporate appropriate human-factors engineering to avoid risk-prone workflows and controls (e.g., memorized mnemonic codes or function keys, long selection lists) that may produce order-entry errors. The order entry functionality should be independent of patient setting (e.g., inpatient, outpatient), and users should be able to combine data (e.g., order history) from all settings without a need for independent searches or screen selections. The system should include an online help function for system navigation and provide notification if another user modifies

the patient record while an order session is ongoing, without losing the session. All displays should contain the patient name, patient location, user name, and function in consistent screen locations. The system should support third-party data entry for prescribers by simultaneous display of the same session in multiple locations and default fields where possible or helpful. The CPOE system should permit user definition of data elements and fields that can be attached to any portion of the database. The system should permit user-friendly, error-free medication order processing by providing the functionalities for the CPOE interface and order processing listed in Figure 9.

Levels of Access. The team will need to determine the levels of access or security permitted to staff throughout the hospital. The team may find it easier to begin with the current level of privileges for existing systems.

In general, pharmacists require a high level of access (full access to medication orders, and in some cases the ability place lab orders) because they cover multiple areas; place, alter, or discontinue orders; and may practice under protocols that require monitoring of laboratory test results. There may be different levels of access within the pharmacy department (e.g., actions by a pharmacy student, intern, or resident may need to be reviewed by a senior pharmacist; pharmacy technicians may require different levels of access, depending on duties). Staff may also need off-site or alternative site access.

In addition to pharmacy personnel access, the design team will need to determine levels of access for other staff members. This should include all categories of physicians that practice at the site (e.g., attendings, specialists, consultants, community clinicians with privileges, residents or other trainees, fellows, and medical students). The medical staff office, medical staff executive committees, or P&T committees may be able to make recommendations for appropriate access based on existing policies. Nursing will need to consider similar access issues and ensure compliance with provider practice acts. Ideally, these issues are addressed by existing policies that will only need to be reviewed and implemented. Other ancillary staff will need to be granted access, depending on their need for information and orders that will be built within CPOE and routed to the appropriate department for action.

User Levels and Co-Signatures. The CPOE system should permit restriction of medication orders by user type, individual order, or class of order. Each medication order should indicate the name and user level of the ordering party. The CPOE system should support the entry of unverified orders and the editing and verification of unverified orders, and this function should be role-based and restricted. The system should also support the creation of reminders or inbox messages for orders that require a co-signature. The pending prescriber co-signature name should default into the field from service, team, or coverage schedules, and there should be an option to override the name. The system should provide the ability to require that all orders be countersigned prior to placing a discharge order if the organization wishes to implement this.

Medication Order Status. Considerations regarding medication order status include the following:

Figure 9. Functionalities for CPOE interface and order processing.**CPOE Interface**

- Multiple active sessions on one display (i.e., ability to put a current order session on hold and review other information, then return to the original work session without losing the work in progress).
- Side-by-side viewing of active order lists and any system-maintained order list (e.g., a standard order set, personal favorites list, or critical path order set).
- Alignment of orders by department while in side-by-side view.
- Switching between applications on the same display without exiting order functions.
- Utilization of all functions via either keyboard or mouse.
- Forward and backward navigation anywhere in the application.
- Access to the Internet from anywhere in the orders application.
- Access from multiple locations (e.g., sign-on, viewing, data entry, and verification at clinical or remote location).
- Order entry with minimal (<3) screen flips and user definition of defaulted fields.

CPOE Medication Order Processing

- Ability to return user to previous screen.
- Online access to error message documentation.
- Hospital-defined error messages.
- Ability to audit and track all errors and alerts.
- Robust search functionality available from all screens.
- Support for coding all diagnoses, tests, and procedures with institutional, departmental, and user-definable subsets of preferred terms (e.g., the appropriate edition of the International Classification of Diseases,⁵⁵ SnoMed CT,⁵⁶ or others).
- Ability to establish cross-references for tests or procedures, including:
 - Information regarding the name of a procedure or test (i.e., the ability to use alternate names for a procedure).
 - Information regarding indications for, execution of, cost of, and medical literature pertinent to a procedure.
 - Diagnosis codes that can be restricted based on type of exam or test.
 - Diagnosis code restrictions that staff can override by direct entry of the code or access to full table for lookup.
 - Ability to enter a diagnosis code along with reason for exam.
 - Ability to maintain orders online for the duration of the patient stay and to display the status of the orders (e.g., open, in process, completed, scheduled to expire, expired) during order inquiry.
 - Ability to store, display, and print patient test instructions as well as preparation instructions for the order.
- Ability to perform global set-up changes (i.e., changes to a master file table element can be optionally set to automatically populate all relevant items throughout the table).
- Ability to update patient service and physician(s).
- Ability to clearly note, flag and color-code order status.
- Option to have active orders remain visible on the same screen while writing new orders.
- Ability to view all orders, including stopped and interrupted (partially entered) orders.
- Automatic assignment of unique order identification numbers used in mapping to other systems, with the order identification number large enough, or based on an algorithm, so that such numbers are not repeated within 5 years.
- Ability to retain multiple order numbers or other unique identifiers from other systems.
- Option to manually update order status, with the ability to restrict such updates to specific order items or specific users or user classes.
- Ability to create user-defined order status.
- One-step cancel/reorder process.
- Discontinue, discontinue/renew, cancel occurrence, and hold order functions.
- Automatic calculations.
- Option to input order information using free text.
- Ability to search for, track, and audit free text orders.
- Ability to drill down for detail from every screen.
- Ability to drill down to the following during the order entry process:
 - Medication and doses, since initial orders include suspended and discontinued orders.
 - Termination date and time of current orders.
 - Allergies (coded).
 - Patient diagnoses (coded).
 - Demographic information.
 - Visit information (medical).
 - Physicians responsible for the patient (resident, attending, and consultant physicians, at a minimum).
 - Active and completed orders with dates and times.
 - Patient location and service.
- Modules with data specific to clinical specialties, including sets for reporting results, CDS, and order sets.

- Whether all orders must be reviewed by a pharmacist before they are active or posted to the MAR.
- If the answer to the above question is yes, the process in which the organization will handle urgent medications that are administered before pharmacist review.
- Should the CPOE system have some medications on override for urgent use? Are these medications always on override or are there alternative methods for ordering them?
- Does the pharmacy have sufficient staff to deal with the volume of orders? Pharmacy will potentially see all changes, i.v. fluid orders, discontinuation orders, and titration orders. Design considerations will need to address the disposition of the orders prior to implementation.
- If a prescriber enters and then changes an order, how are those two orders reconciled into one order?
- How does the system handle an order by a physician assistant or student that requires a co-signature before becoming active?
- Do hold orders need a defined duration to be accepted? Do these orders automatically discontinue if on hold for a certain amount of time?

Except in urgent situations as described by the Joint Commission,⁵⁷ a pharmacist should verify every medication order prior to drug dispensing and administration. Once verified by a pharmacist, the order should populate the pharmacy computer system, generate labels and other items necessary for dispensing, release the drug in the automated dispensing device (if applicable), and populate the eMAR as an active order. The order should be available to the eMAR as soon as it is placed, but it should be clear to the nurse whether the pharmacist has verified the order or not.

Order History. The CPOE system should permit viewing of orders from all previous patient encounters regardless of enterprise location, setting, or patient status. The system should be capable of storing and retrieving previous patient order lists and sorting, reporting, and printing patient order lists by date and date range, setting, patient status (e.g., discharge), service, department, and provider.

The system should allow pharmacists to maintain eMARs and permit online updates, provide online capability to automatically generate a hard copy of eMARs for downtime back-up, provide the ability to display and/or print patient medication profiles or eMARs on demand or at a specified time, and include the ability to have multiple formats that are definable by systems-level staff.

Documentation in the eMAR. The CPOE system should seamlessly build the eMAR from orders in real time. Some institutions may want medication administration time changes to be modifiable from the eMAR, and the eMAR may have a bi-directional interface to the pharmacy information system (if it is not an integrated system). The system should provide the ability to enable bar-code medication documentation. Pharmacist order validation should automatically update the eMAR. The pharmacy and nursing departments should work together to ensure that the eMAR is designed to be readable and user-friendly from the nurse's perspective. Pharmacists and nurses should have the ability to add or delete patient allergies, enter special instructions,

change administration times, and place medication orders on or remove them from hold or conditional status. Changes made to administration times in the eMAR should back-populate the CPOE and pharmacy information systems.

Medication Orderable Design and Build Considerations

The design and build of the medication orderables are key tasks in implementing the CPOE system. Care should be taken in designing and building the formulary or formularies, as well as the standard orders and order sets that are built from the formulary. The pharmacy department must have direct involvement in this task.

The CPOE formulary cannot be simply a copy of the pharmacy inventory. Prescribers need to have the orderables constructed to match how they order medications (therapeutic entity), rather than how the pharmacy maintains medication inventory (dosage form/product). In addition, care must be exercised when deciding on the default dose, frequency, and route values for items that will be displayed to the prescriber and in developing the construction of standard orders. Medication errors can result from a hurried prescriber accepting the default that he or she assumes must be correct.²⁵ The CPOE system should be able to generate formulary lists by generic name, trade name, and dosage form.

The CPOE system should allow routine online updating of the formulary and clinical checks of information without system functionality downtime. The system should provide authorized personnel the ability to maintain and display the formulary with pertinent data (e.g., formulary code, generic name, trade name, national drug code [NDC], or American Hospital Formulary Service [AHFS] number), while limiting access to certain formulary data by role. The CPOE system should include the ability to identify whether an i.v. with a medication additive is to be handled as a large-volume i.v. or as a small-volume i.v. for appropriate handling within the pharmacy department for compounding and dispensing. The system should allow the ability to make changes to the medication identifier (NDC or RxNorm identifier), communicate those changes to other systems, and receive changes from other systems.

Build Considerations

IT analysts design and build the system from documents or order sets reviewed and approved by the multidisciplinary group. Standard IT processes should be followed, beginning with the design phase. Once the design has been approved, IT staff should build the system in a test environment. A test environment protects from mishaps in the live (or "production") environment. It is important for the test environment to match the production environment so that testers get a true feel for how the build will work and interact. IT staff should meet with nursing and pharmacy throughout building and testing phases to resolve any issues that may arise.

After the builder is satisfied that the requested build or order set is complete, the builder should then develop a testing plan. The builder should work through the test plan initially and sign off when the build works as designed.

Next, pharmacy and nursing should perform testing. This testing should involve patient scenarios throughout

the patient's visit. Pharmacy is integral to this process and should ensure proper medication management and workflow. When the build passes pharmacy and nursing testing, physicians should review, test, and sign off.

When all aspects have been tested and fixed, and any necessary education is completed, the build may be moved to production. Follow-up is critical to ensure the build meets the needs of providers and is not adversely affecting ancillary staff. A mechanism to report issues quickly must be established, so that the implementation team can investigate and resolve them. The CPOE group should maintain reports of problems and review those lists for recurrent issues. Providing feedback and updates to the persons reporting problems is vital to progression of the project. Clinicians need to know they have been heard and resolution is being sought.

Dependent or Joined Orders. Support for dependent or joined orders is important in the case of i.v. medications and the diluent used for administration, two drugs to be taken together, or a drug and a measurement requirement (e.g., digoxin and pulse rate). The CPOE system needs to make it easy for the prescriber to order these types of formulary items. The system should be flexible enough for the prescriber to select the drug form and size or indicate the diluent for an i.v. piggy-back when ordering if so desired or to allow these choices to be made once the order reaches the pharmacy system.

Order Sets. Requiring providers to use a CPOE system requires a change in workflow, and many fear it may increase the time clinicians spend processing orders.⁴⁶ Configuring pre-constructed order sentences and order sets prior to implementing CPOE may increase speed, accuracy, and acceptability of CPOE.^{27,28,58} Careful deliberation is needed prior to the creation of CPOE order sets, including consideration of how order sets are currently developed and revised (e.g., by department or by individual practitioners), what the process to propose and review order sets is, and what level of medical oversight is in place for order set development and use. It is also important to understand ordering patterns when developing order sets for use by clinicians. Many organizations use this opportunity to improve and standardize across important aspects of care, such as post-operative nausea and vomiting or pain management, as well as move to evidence-based order sets from their legacy order sets.²⁸

The system should permit development of specific admission pathways (e.g., order sets capable of including any type of order and intervention) and integrate with data documented elsewhere in the EHR (e.g., medical histories, medication lists, laboratory results, diagnostic images, clinical documentation, progress notes, narrative summaries [such as operative reports or consultations]). Order set availability should be limitable by user, user role, location, service, or patient status or diagnosis. The system should permit an unlimited number of orders within an order set and an unlimited number of order sets within departments, across departments, and with user-definable time parameters. Order sets can include nursing orders, tests, and medications, and should include appropriate laboratory tests at appropriate intervals to assist in monitoring therapy. Though many systems allow users to create and save their own order sets in a favorites list, this flexibility needs to be weighed against the desire to standardize care by allowing hospital-based order

sets only.²⁸ Discontinuation of an order set should trigger the automatic ability to review, edit, or discontinue all linked orders.

Because the CPOE system may permit initiation of standard order sets with a single action (mouse click, keyboard stroke, etc.), order sets' ease of use may lead to inappropriate or excess medications being ordered. Order sets should be allowed to include linked orders, but orders grouped in a standard order set need not be linked. The institution should decide whether all orders in the set are going to be active once they are signed or if prescribers are required to actively check and click on each medication before signing.

The CPOE system should require designation of an owner (i.e., department, service, person, or role) for each order set. CPOE order sets should be reviewed on a periodic basis for therapy updates. Item and service maintenance should be performed at the departmental level, with updates in item or service definition flagged for review by the owner of the standard order set containing that item or service (i.e., the change triggers a report that the order set requires review). The CPOE system should support restriction of departmental or service standard order set creation or editing by role or individual.

The CPOE system should support standard order set maintenance and review by

- Grouping order sets by department/service,
- Dating the creation and review of order sets,
- Providing periodic (user-defined intervals or dates, or as-needed) reporting of standard order sets that require review by owner (department, service, person, or role), and
- Permitting global changes.

Critical Pathways and Protocol Order Sets. Critical pathways and paper-based order sets, a very basic form of CDS already widely used in hospitals, provide a starting point in efforts to standardize care and improve quality and safety through the CPOE system. With the implementation of evidence-based order sets, organizations can provide the prescriber with a direct link to the electronic literature supporting the recommended practice. The work of synthesizing and classifying the available evidence is done by organizations such as the National Guideline Clearinghouse⁵⁹ and the Cochrane Database of Systematic Reviews.⁶⁰ Organizations may incorporate these guidelines into electronic order sets and critical pathways, in addition to providing the link to give prescribers point-of-care access to the evidence-based literature at the time of order entry.

The CPOE system should support all functions listed under general order sets for critical pathways and protocol order sets. The system should provide a default set of protocols that are available by service and physician and a default set of protocols that are restricted by location. The CPOE system should include an alert system for orders not completed within user-defined time parameters or time parameters required by critical paths or research protocol.

Medication Order Linking. The CPOE system should include the ability to identify orders as linked and sequential or mutually exclusive or time off-set, and to specify intervals, as well as cascade changes in future orders to maintain sequence and timing. It should permit an order stop to automatically bring up any linked orders for re-verification, with

the default being to cancel unless re-verified. The system should provide automatic re-sequencing of future orders if any item identified as sequential is moved on the timeline, and it should permit linked orders (i.e., reflexive occurrences that trigger other procedures) that cascade through multiple levels.

Favorites Lists. The CPOE system should permit use of favorites lists by individual user that may include orders for multiple departments (e.g., laboratory, pharmacy, radiology). The system should provide default components of medication prescribing (“Sigs”), such as dose route frequency, and length of order, that are user-definable at the nursing unit level and that have discharge orders or discharge worksheet functionality. The system should provide default Sigs and permit users to save favorite Sigs in user favorites. Users should be able to create favorites lists that include orders from multiple departments on one list. Favorites lists should be fully editable on an ad hoc basis for an active order session, and user-specific favorites lists should be editable by the user. Users should be able to designate any order list as a favorite and may name or rename the list ad hoc (i.e., the save function automatically prompts for name, defaulting to the existing name if available). There should be an option to save an order list as a favorite, either as a new favorite or as a replacement for an existing favorite; that option should be available during any ordering session. Favorites lists should be allowed to contain ordering details that default into the order, and default details should be editable and replaceable during order entry. The CPOE system should support context-specific favorites lists by user, nursing unit, service, and diagnosis, and by combinations of user and diagnosis or by combinations of user, diagnosis, and setting (e.g., outpatient, inpatient). User favorites lists should be copied and shared easily, and the system should allow favorites lists to be built by opening and then editing standard order sets and saving as a favorite. Favorites lists may also include reminders. The system should permit review of favorites lists.

Pharmacy Department Considerations

The ideal CPOE system will have to be integrated with or have a fully functional bi-directional interface with the hospital’s pharmacy computer system so that orders entered or modified in one system will populate fields in the other system, avoiding the need for dual order entry. The bi-directional feature of an interface is important because it prevents potentially dangerous discrepancies between data in the pharmacy and EHR systems and removes the transcription step of the medication-use process. In addition, if the distribution and administration components of medication management are not linked, then documentation and billing will not be either, causing more opportunities for error and audit problems.

In their day-to-day interaction with the CPOE system, pharmacists should be working primarily in the pharmacy system, which has all relevant patient information fully integrated with the EHR and CPOE module. The pharmacist’s roles include verifying all orders, reviewing and responding to alerts, and clinical monitoring of the patient. The pharmacist should have security privileges to enter and modify orders under protocol (such as formulary or formulation changes). The pharmacist should see all orders within a particular group of orders so that they can see the con-

text in which each individual drug order was prescribed. Additionally, any functionality to help the pharmacist prioritize the review and approval of orders will improve the care of patients.

Pharmacists should receive and work with orders electronically in a queue. Patients with stat orders should appear at the top of the list and be clearly differentiated from less urgent orders. Pharmacists should have the ability to screen their view of orders based on the nursing units they are responsible for on a given shift. At no time should a pharmacist be able to view orders for more than one patient at the same time.

When working with paper orders, pharmacists often gain insight into the medication orders from the context of the surrounding patient care orders. CPOE systems should preserve that context so that pharmacists can view an order in terms of the other therapies, tests, nutrition, and nursing care surrounding it.

Communication Among Departments

The CPOE system should allow for notification of clinicians for pending orders needing signature via e-mail, pager, text message, or inbox message. Pharmacist order notification should be allowed via printout, work queue, e-mail message, system message, or pager. The default method for receiving notification of orders should be definable by the department or service, and the system should support special notification methods for specific services or items different from the departmental or service default, without affecting summary reporting by department. Users should be able to print orders to alternate locations and to send messages, orders, and alerts to additional departments (including information about scheduling and priority of orders) as a single order is being entered or completed. The CPOE system should have an option that order placement generates user-defined worklists. The system should also provide the ability to e-mail patient and preparation instructions and to reference on-call lists.

Education and Training of Health Care Providers

The rate of adoption of the new CPOE system may be directly linked to the extent of training provided to users prior to and during the implementation. One cannot spend too much time training users, as the change the new system entails will be overwhelming. This training can be in the form of formal classroom training, local expert training, or “at-the-elbow” support and training (the type of training typically most welcomed by physicians) during implementation. Organizations may find the most success in using a combination of all three. The more familiar the users are with the system at the time of implementation, the easier the transition will be.

The facility should train and employ a group of prescriber “super users.” These users will support the go-live, help the institution refine the CPOE system to be as efficient as possible, and serve as liaisons and CPOE champions to the other members of the medical staff. There should be ongoing, open dialogue with leadership and medical staff members to continually improve the system.

Each training session should be geared toward the type of user, since utilization will differ by clinician type (e.g., physician, respiratory therapist, nurse, pharmacist, laboratory technician). The initial training of users is important, but ongoing training for new users, changes in programming, and functionality require that training be given a high priority after transition to the new system.

Overview of System. The initial introduction to the system should familiarize the user with the layout of the system. It should review toolbars and menus of each application. The first glimpse should include any definitions that are new or to which meanings may be different from the current process.

Accessing Data. This section of training should familiarize the user with the various methods for accessing data. It should provide information on sorting and filtering data. Because access to data will vary based upon the type of user, separating different user types for training purposes at this stage may be beneficial, and this is a good time to discuss security and privileges.

Documenting Information. This section should teach users how to document information pertinent to their practices. These tasks would include adding basic patient information and documentation onto flow sheets, as well as clinical progress notes.

Orders. The training sessions on medication orders will be the most comprehensive. Some users will be limited to ordering tests or procedures specific to their practices. Physicians, nurses, and pharmacists, however, will spend a large percentage of their time in the CPOE system working with orders. Time should be taken to demonstrate each type of order. After the demonstration, users should practice working with all types of orders that they may process in various scenarios. Though documented information may be sparse in test domains, practicing with realistic patient scenarios will provide the best training results and prepare the user for success when using the live CPOE system.

Pilot Project. A pilot with a defined scope is advisable at the beginning of the implementation phase. Organizers should consider the length of the pilot, which patients will be included, what the objectives of the pilot are (i.e., testing system performance, workflow, completeness of ordering), and what happens at the conclusion of the pilot (e.g., more programming, more testing, another pilot, or live roll-out). Consideration should be given to type of prescriber/practitioner, order types and number of patient transfers into or out of pilot test area as well as flow of patient information to non-pilot areas. Because user feedback is a valuable objective of the pilot, organizers should develop and use a formal evaluation tool for the pilot clinicians. A time analysis should be performed, comparing how long it takes the pharmacy to process orders with the CPOE system versus their previous workflow. If the time analysis demonstrates a negative impact on workload, the facility may consider making appropriate staffing adjustments. These adjustments will vary, based on the percentage of orders directly entered by the prescriber, and should be continually assessed. True final measurement of process performance capabilities will

likely not be realized until implementation processes have been completed and stabilized. A time analysis should also be performed comparing how long it takes CPOE-trained nursing staff to administer and document medications in the CPOE system versus the manual system. This analysis should determine whether time is saved by eliminating manual transcription of orders and manual development and maintenance of MARs. If the time analysis demonstrates a negative impact on workload, the facility should make appropriate staffing adjustments. These adjustments will vary, based on the percentage of orders directly entered by the prescriber, and should be continually assessed.

Conclusion

These guidelines provide guidance to pharmacists in hospitals and health systems on planning for and implementing safe CPOE systems. Pharmacists should utilize their unique knowledge and skills as part of the interdisciplinary CPOE planning and implementation team. Participation by pharmacists is critical in defining the vision, goals, and objectives of the CPOE system; establishing essential metrics to measure the success of CPOE system implementation; re-engineering the medication-use process as part of CPOE system implementation; determining the functionality that ensures the safety of the CPOE system; planning for CDS; and educating and training health care providers to use the CPOE system. Finally, for optimal benefits to patients, organizations should realize that the implementation is merely the beginning and that pharmacists should continue to take a central role in ongoing system optimization and continued CDS implementation.

References

1. Kohn LT, Corrigan JM, Donaldson MS, eds. *To err is human—building a safer health system*. Washington, DC: National Academy Press; 1999.
2. Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med*. 1991; 324:370–6.
3. Leape LL, Brennan TA, Laird NM, et al. The nature of adverse events in hospitalized patients: Results from the Harvard Medical Practice Study II. *N Engl J Med*. 1991; 324:377–84.
4. Thomas EJ, Studdert DM, Burstin HR, et al. Incidence and types of adverse events and negligent care in Utah and Colorado. *Med Care*. 2000; 38:261–71.
5. Phillips DF, Christenfeld N, Glynn LM. Increase in U.S. medication-error deaths between 1983 and 1993. *Lancet*. 1998; 351:643–4.
6. Bates DW, Spell N, Cullen DJ, et al. The costs of adverse drug events in hospitalized patients. *JAMA*. 1997; 277:307–11.
7. Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events. Implications for prevention. ADE Prevention Study Group. *JAMA*. 1995; 274:29–34.
8. Corrigan JM, Donaldson MD, Kohn LT, et al. Crossing the quality chasm: a new health system for the 21st

- century. Washington, DC: National Academy Press; 2001.
9. Birkmeyer JD, Dimick JB. The Leapfrog Group's Patient Safety Practices, 2003: The Potential Benefits of Universal Adoption. Leapfrog Group; February 2004. www.leapfroggroup.org/media/file/Leapfrog-Birkmeyer.pdf (accessed 2009 Jan 22).
 10. National Quality Forum (NQF). Safe Practices for Better Healthcare—2009 Update: A Consensus Report. Washington, DC: NQF; 2009.
 11. American Recovery and Reinvestment Act of 2009 [ARRA] (P.L. 111-5, 123 Stat. 115-521). <http://edocket.access.gpo.gov/2010/E9-31217.htm> (accessed 2010 May 19).
 12. Bates DW, Teich JM, Lee J, et al. The impact of computerized physician order entry on medication error prevention. *J Am Med Inform Assoc.* 1999; 6:313–21.
 13. Bates DW, Leape LL, Cullen DJ, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA.* 1998; 280:1311–6.
 14. Hunt DL, Haynes RB, Hanna SE, et al. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systemic review. *JAMA.* 1998; 289:1330–46.
 15. Amarasingham R, Plantinga L, Diener-West M, et al. Clinical information technologies and inpatient outcomes: a multiple hospital study. *Arch Intern Med.* 2009; 169:108–11.
 16. Bates DW. The effects of health information technology on inpatient care. *Arch Intern Med.* 2009; 169:105–7.
 17. Wolfstadt JI, Gurwitz JH, Field TS, et al. The effect of computerized physician order entry with clinical decisions support on the rates of adverse drug events: a systematic review. *J Gen Intern Med.* 2008; 23:451–8.
 18. Ammenwerth E, Schnell-Inderst P, Machan C, et al. The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc.* 2008; 15: 585–600.
 19. Eslami S, de Keizer NF, Abu-Hanna A. The impact of computerized physician medication order entry in hospitalized patients—a systematic review. *Int J Med Informatics.* 2008; 77:365–76.
 20. Teich JM, Merchia PR, Schmitz JL, et al. Effects of computerized physician order entry on prescribing practices. *Arch Intern Med.* 2000; 160:2741–7.
 21. Chaudry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency and costs of medical care. *Ann Intern Med.* 2006; 144:E-12–22.
 22. Weiner JP, Kfuri T, Chan K, et al. “e-Iatrogenesis”: the most critical unintended consequence of CPOE and other HIT. *J Am Med Inform Assoc.* 2007; 14:387–8.
 23. Healthcare Information and Management Systems Society (HIMSS) Enterprise Information Systems Steering Committee. Clinical perspectives on enterprise information technology. www.himss.org/content/files/ClinicalPerspectives_whitepaper_052907.pdf (accessed 2009 Aug 26).
 24. Healthcare Information and Management Systems Society (HIMSS). Electronic health record. www.himss.org/ASP/topics_ehr.asp (accessed 2009 Aug 26).
 25. Koppel R, Metlay JP, Cohen A, et al. Role of computerized physician order entry systems in facilitating medication errors. *JAMA.* 2005; 293:1197–203.
 26. Han YY, Carcillo JA, Venkataraman ST, et al. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. *Pediatrics.* 2005; 116:1506–12.
 27. Kuperman GJ, Bobb AM, Payne TH, et al. Medication-related clinical decision support in computerized provider order entry systems: a review. *J Am Med Inform Assoc.* 2007; 14:29–40.
 28. Bobb AM, Payne TH, Gross PA. Viewpoint: controversies surrounding use of order sets for clinical decision support in computerized provider order entry. *J Am Med Inform Assoc.* 2007; 14:41–7.
 29. Bates DW. Computerized physician order entry and medication errors: finding a balance. *J Biomed Informatics.* 2005; 38:259–61.
 30. Kaushal R, Shojania KG, Bates DW. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. *Arch Intern Med.* 2003; 163:1409–16.
 31. Bobb A, Gleason K, Husch M, et al. The epidemiology of prescribing errors: the potential impact of computerized prescriber order entry. *Arch Intern Med.* 2004; 164:785–92.
 32. Kilbridge PM, Classen DC. A process model of inpatient medication management and information technology interventions to improve patient safety. VHA Research Series, vol. 1. Irving, TX: VHA Inc.; 2001.
 33. Pedersen CA, Gumpfer KF. ASHP national survey on informatics: Assessment of the adoption and use of pharmacy informatics in U.S. hospitals—2007. *Am J Health-Syst Pharm.* 2008; 65:2244–64.
 34. Khajouei R, Jaspers MW. The impact of CPOE medication systems' design aspects on usability, workflow and medication orders: a systematic review. *Methods Inf Med.* 2010; 49:3–19.
 35. Niazkhani Z, Pirnejad H, Berg M, et al. The impact of computerized provider order entry systems on inpatient clinical workflow: a literature review. *J Am Med Inform Assoc.* 2009; 16:539–49.
 36. Wietholter J, Susan Sitterson S, Allison S. Effects of computerized prescriber order entry on pharmacy order-processing time. *Am J Health-Syst Pharm.* 2009; 66:1394–8.
 37. Kaushal R, Jha AK, Franz C, et al. Return on investment for a computerized physician order entry system. *J Am Med Inform Assoc.* 2006; 13:261–6.
 38. Campbell EM, Sittig DF, Ash JS, et al. Types of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc.* 2006; 13:547–56.
 39. Campbell EM, Guappone KP, Sittig DF. Computerized provider order entry adoption: implications for clinical workflow. *J Gen Intern Med.* 2009; 24:21–6.
 40. Singh H, Mani S, Espadas D, et al. Prescription errors and outcomes related to inconsistent information transmitted through computerized order entry: a prospective study. *Arch Intern Med.* 2009; 169:982–9.

41. Bonnabry P, Despont-Gros C, Grauser D, et al. A risk analysis method to evaluate the impact of a computerized provider order entry system on patient safety. *J Am Med Inform Assoc.* 2008; 15:453–60.
42. Kozakiewicz JM, Benis LJ, Fisher SM, et al. Safe chemotherapy administration: using failure mode and effects analysis in computerized prescriber order entry. *Am J Health-Syst Pharm.* 2005; 62:1813–6.
43. Coles G, Fuller B, Nordquist K, et al. Using failure mode effects and criticality analysis for high-risk processes at three community hospitals. *Jt Comm J Qual Patient Saf.* 2005; 31:132–40.
44. Beuscart-Zépher MC, Pelayo S, Bernonville S. Example of a human factors engineering approach to a medication administration work system: potential impact on patient safety. *Int J Med Inform.* 2010; 79:e43–57.
45. Kuperman GJ, Gibson RF. Computer physician order entry: benefits, costs, and issues. *Ann Intern Med.* 2003; 139:31–9.
46. Bates DW, Boyle DL, Teich JM. Impact of computerized physician order entry on physician time. *Proc Annu Symp Comput Appl Med Care.* 1994:996.
47. McGovern K. 10 Golden rules for administering drugs safely. In: Preventing medication errors. Springhouse, PA: Springhouse; 1994:2–3.
48. Osheroff JA, Pifer EA, Teich JM, et al. Improving outcomes with clinical decision support: an implementer's guide. Chicago: Healthcare Information and Management Systems Society; 2005.
49. Osheroff J, ed. Improving medication use and outcomes with clinical decision support: a step-by-step guide. Chicago: Healthcare Information and Management Systems Society; 2009.
50. Weingart SN, Toth M, Sands DZ, et al. Physicians' decisions to override computerized drug alerts in primary care. *Arch Intern Med.* 2008; 163:2625–31.
51. Igboechi CA, Ng CL, Yang CS, et al. Impact of computerized prescriber order entry on medication errors at an acute tertiary care hospital. *Hosp Pharm.* 2003; 38:227–31.
52. Hsieh TC, Kuperman GJ, Jaggi T, et al. Characteristics and consequences of drug allergy alert overrides in a computerized physician order entry system. *J Am Med Inform Assoc.* 2004; 11:482–91.
53. Nebeker JR, Hoffman JM, Weir CR, et al. High rates of adverse drug events in a highly computerized hospital. *Arch Intern Med.* 2005; 165:1111–6.
54. Paterno MD, Maviglia SM, Gorman PN, et al. Tiering drug-drug interaction alerts by severity increases compliance rates. *J Am Med Inform Assoc.* 2009; 16:40–6.
55. International classification of diseases, ninth revision, clinical modification (ICD-9-CM). www.cdc.gov/nchs/about/otheract/icd9/abtcd9.htm (accessed 2009 Jan 27).
56. *SnoMed Clinical Terms (SnoMed CT)*. www.nlm.nih.gov/research/umls/Snomed/snomed_main.html (accessed 2009 Aug 28).
57. Medication Management Standard MM.4.10—preparing and dispensing. In: Comprehensive accreditation manual for hospitals. Oakbrook Terrace, IL: Joint Commission on the Accreditation of Healthcare Organizations; 2006:MM-10.
58. Payne TH, Hoey PJ, Nichol P, et al. Preparation and use of preconstructed orders, order sets, and order menus in a computerized provider order entry system. *J Am Med Inform Assoc.* 2003; 10:322–9.
59. National Guideline Clearinghouse. www.guideline.gov (accessed 2009 Jan 22).
60. Cochrane Database of Systematic Reviews. www.cochrane.co.uk (accessed 2009 Jan 22).

Appendix—Glossary of Terms and Abbreviations

Adverse drug event (ADE): ASHP defines a significant ADE as any unexpected, unintended, undesired, or excessive response to a drug that

1. Requires discontinuing the drug (therapeutic or diagnostic),
2. Requires changing the drug therapy,
3. Requires modifying the dose (except for minor dosage adjustments),
4. Necessitates admission to a hospital,
5. Prolongs stay in a health care facility,
6. Necessitates supportive treatment,
7. Significantly complicates diagnosis,
8. Negatively affects prognosis, or
9. Results in temporary or permanent harm, disability, or death.

Bar-code-assisted medication administration (BCMA): A methodology involving the use of scanners and software to verify all medications electronically before they are administered to patients. These systems may also document the medication in the eMAR.

Clinical decision support (CDS): Clinical decision support systems are interactive computer programs or other tools, which are designed to assist physicians and other health professionals with decision making tasks usually at the point of care.

Computerized provider-order-entry; alternatively, computerized prescriber-order-entry (CPOE): An electronic system that health care professionals can use to enter drug, treatment, and test orders and transmit the orders directly to the department responsible for fulfilling the order.

e-iatrogenesis: Patient harm caused at least in part by the application of health information technology including but not limited to the systems and/or the design and implementation of the system.

Electronic health record (EHR): An electronic record of health-related information on an individual that conforms to nationally recognized interoperability standards and that can be created, managed, and consulted by authorized clinicians and staff across more than one health care organization.

Electronic medication administration record (eMAR): A version of the medication administration record viewable online and not printed.

Electronic medical record (EMR): An electronic record of health-related information on an individual that can be created, gathered, managed, and consulted by authorized clinicians and staff within one health care organization.

Enterprise information system: Broader system that integrates clinical systems such as an EHR and business systems such as a scheduling and/or financial systems and quality reporting systems.

Leadership: Within a health-system, leadership may address three leadership groups: The governing body, the chief executive and other senior managers, and the leaders of the licensed independent practitioners.

Legal medical record (LMR): The legal health record is the documentation of health care services provided to an

individual during any aspect of health care delivery in any type of health care organization. It is consumer or patient-centric. The legal health record contains individually identifiable data, stored on any medium, and collected and directly used in documenting health care or health status.

National drug code (NDC): A universal 11-digit product identifier used in the United States for drugs intended for human use. The Drug Listing Act of 1972 requires registered drug establishments to provide the Food and Drug Administration (FDA) with a current list of all drugs manufactured, prepared, propagated, compounded, or processed by it for commercial distribution.

Orderable: An authoritative direction or instruction from a prescriber to perform a task (e.g., a radiology test or administer a medication or treatment).

Medication administration record (MAR): Medication administration record usually handwritten or printed from an electronic pharmacy information system.

Personal health record (PHR): An electronic record of health-related information on an individual that conforms to nationally recognized interoperability standards and that can be drawn from multiple sources while being managed, shared, and controlled by the individual.

RxNorm: RxNorm is a standardized nomenclature for clinical drugs and drug delivery devices and is produced by the National Library of Medicine.

Sponsorship: An identified executive or clinical leader who assumes responsibility for another person or a group during a period of project planning implementation follow-up.

Systematized nomenclature of medicine (SNOMed): A multiaxial, hierarchical classification system. As in any such system, a disease may be located in a body organ, which results in a code in a topography axis and may lead to morphological alterations represented by a morphology code.

Workflow: The flow or progress of work done by a company, industry, department, or person.

Developed through the ASHP Section of Pharmacy Informatics and Technology and approved by the ASHP Board of Directors on September 24, 2010.

A work group of the ASHP Section of Pharmacy Informatics and Technology Section Advisory Group on Clinical Information Systems is gratefully acknowledged for developing these guidelines: Anne M. Bobb, B.S.Pharm.; Jennifer Boehne, Pharm.D.; W. Lynn Ethridge, Pharm.D.; J. Chad Hardy, Pharm.D., M.S.; Randy Herring, B.S.Pharm.; Richard S. Jacobs, Pharm.D.; Michael A. Jones, Pharm.D.; Timothy W. Lynch, Pharm.D., M.S.; Leslie R. Mackowiak, M.S.; Tommy J. Mannino, B.S.; Jayson J. Przybyla, Pharm.D.; Brendan J. Reichert, M.S.; Rane M. Runnebaum, Pharm.D.; Nancy R. Smestad, M.S.; David L. Troiano, M.B.A., MSIA; Laura L. Tyndall, Pharm.D.; and Lori Wright, Pharm.D.

ASHP also gratefully acknowledges the contributions of the following people: Bruce W. Chaffee, Pharm.D.; Toby Clark, M.Sc.,

FASHP; Kate Farthing, Pharm.D., BCPS; Burt W. Finkelstein, Pharm.D.; William L. Fritz, M.S., FASHP; Kimberly A. Galt, Pharm.D., FASHP; Barry R. Goldspiel, Pharm.D., FASHP; Frances M. Jordan, M.B.A., FASHP; Renee B. Marino, Pharm.D.; Kevin C. Marvin, M.S., FASHP; Steven Meisel, Pharm.D.; Alicia S. Miller, M.S.; Sandi Mitchell, M.S.I.S., FASHP; Kuldip R. Patel, Pharm.D.; Alicia B. Perry, Pharm.D.; John Poikonen, Pharm.D.; Mark H. Siska, B.S.Pharm.; and Mary Windle, Pharm.D.

ASHP also acknowledges the following organizations and individuals for reviewing drafts of these guidelines (review does not imply endorsement): American Academy of Family Physicians (AAFP); American Association of Critical Care Nurses (AACCN); American Health Information Management Association (AHIMA); American Hospital Association (AHA); California Society of Health-System Pharmacists (CSHP); Healthcare Information and Management Systems Society (HIMSS); Jeanine (Porter) Abrons, Pharm.D., M.S.; Christel Anderson (HIMSS); Dan Buffington; Peggy Brashear, B.S.Pharm.; Tim R. Brown, Pharm.D., FASHP; Dominick A. Caselnova III, M.H.A.; Thomas W. Cooley, M.B.A.; Debby Cowan, Pharm.D.; Michele Danish, Pharm.D., FASHP; Neil Davis; Charlie De la Torre; Robert DeChristoforo, M.S., FASHP; Jean Douglas, Pharm.D.; Brent R. Ekins, Pharm.D., DABA; Elizabeth Fang, Pharm.D.; Tim Lanese, M.B.A., FASHP, CPHIMS; Lisa Gunther Lum, Pharm.D., FASHP, FCSHP; Robi Hellman, RN, MSN, CNS (AACCN); James M. Hoffman, Pharm.D., M.S., BCPS; Carol J. Hope, Pharm.D., M.S.; Amey Hugg; Joan E. Kapsunik-Uner, Pharm.D., FCSHP; Linda L. Kloss, RHIA, FAHIMA (AHIMA); Ronald E. Lay, M.S.; Jeff Little, Pharm.D.; Bob Lobo, Pharm.D.; LTC Eric M. Maroyka, Pharm.D., BCPS; Greg Matsuura, Pharm.D., BCPS; Patrick J. McDonnell, Pharm.D.; Michael Gregory, Pharm.D., M.B.A., BCPS; Robert Moore, B.S.Pharm., BCPS; Susan J. Morikawa, Pharm.D., BCPS; Kevin Olsen, RN, BSN; Peg Panella-Spangler M.S.; Christine Pavlak, M.H.A., FASHP; Stephanie C. Peshek, Pharm.D., FASHP; Tommie Peterson; Minh James Pham, Pharm.D.; James A. Ponto, M.S., BCNP, FASHP; Donald W. Rucker, M.D.; Richard Sakai; Kevin Scheckelhoff; Thomas R. Schafer, Pharm.D., BCPS; Terry Seaton, Pharm.D.; Suzanne Shea; Pamela Shellner, M.A., RN (AACCN); Clyde Spence, Pharm.D., M.B.A.; Richard L. Stambaugh, Pharm.D., M.S., BCPS; Craig S. Stern, Pharm.D., M.B.A.; Scott H. Takahashi, Pharm.D., FCSHP (CSHP); Dennis A. Tribble, Pharm.D.; Jody Jacobson Wedret, FASHP, FCSHP; Rich Umbdenstock (AHA); Ray Vrabel, Pharm.D.; Steven E. Waldren, M.D., M.S. (AAFP); Eric Weber; Barbara White, M.S., PMP, FASHP.

Copyright © 2011, American Society of Health-System Pharmacists, Inc. All rights reserved.

The bibliographic citation for this document is as follows: American Society of Health-System Pharmacists. ASHP guidelines on pharmacy planning for implementation of computerized provider-order-entry systems in hospitals and health systems. *Am J Health-Syst Pharm.* 2011; 68:e9–31.