

Discussion Paper

Computer Physician Order Entry (CPOE)

Prepared by:

Catherine Ormond
Institute for Health Policy
Muskie School of Public Service
Portland, Maine

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For additional copies of this report please contact
Catherine Ormond
Institute for Health Policy
Muskie School of Public Service
207-780-4015, cormond@usm.maine.edu

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Executive Summary

Real-time checks for contra-indications, access to extensive medication information, and availability of key patient information are some of the computer physician order entry (CPOE) functions designed to improve patient safety. Well-designed, aggressively tested, and completely integrated CPOE systems show promise for reducing medication errors. However, CPOE is not merely a complex information technology to be added to a hospital's suite of information technology systems. By its nature, CPOE reconfigures hospital operations and workflow and affects virtually all clinical operations. It takes substantial clinical staff time and support during the implementation phase and, as a result, has been slow to take hold despite early and ongoing support from the Institute of Medicine, AHRQ, the National Quality Forum, and the Leapfrog Group.

Early adopters in large tertiary care hospitals, with capabilities for funding the considerable start up costs associated with CPOE, have provided the bulk of the studies of CPOE experience to date. As more hospitals gain experience and report their use of CPOE in different environments, health care facilities contemplating implementation will benefit. CPOE, a priori, does not reduce medication errors. Indeed, it has been shown to facilitate errors in environments lacking comprehensive management, coordination, a well-designed system, and/or continuous improvement processes. It is a complex system, sensitive to a wide variety of influences including design flaws, poor training, fragmented processes, inadequate or excessive displays of information, any of which can lead to disuse or worse.

Currently, there are no comprehensive CPOE evaluation tools, guidelines, best practices, or performance measures to assist health care facilities in planning and implementation. The National Quality Forum offers broad CPOE functional standards; the Leapfrog Group is developing a clinical decision test for CPOE systems. The United States Pharmacopeia is working on rules for decision support and the Joint Commission on Accreditation of Health Care Organizations is strengthening its medication safety goals and offering suggestions on CPOE implementation.

Until national standards and evaluation criteria are established, organizations wishing to evaluate the outcome of CPOE systems implementation might follow the example of the early adopters who provided evidence of CPOE efficacy by showing decreases in their adverse drug event rates after CPOE implementation.

Purpose and Scope of Review

The Maine Quality Forum contracted with the Muskie School of Public Service to conduct this review of the components, functions, and emerging trends of computer physician order entry (CPOE) systems designed to improve patient safety and health care quality.

This is not an exhaustive study and there are several limitations. This study relies on secondary research. The issue of CPOE is a ‘moving target’ with frequent developments in the research and in the marketplace. We have examined current literature to better understand potential implications in Maine; however, much of the CPOE experience has been in large, urban, tertiary care teaching hospitals which have limited relevance to Maine’s environment.

This paper is organized to first explain the basic attributes and current standards of CPOE, then review seminal literature, discuss cautions for evaluation, highlight cost considerations, and speculate on possible future CPOE findings.

CPOE Definition

What is CPOE?

CPOE is not a technology, rather it is a design (or redesign) of clinical processes that integrates technology to optimize physician ordering of medications, laboratory tests, etc.^{1,2} At its core is an interactive decision support system that is based on rules that may be adapted by the hospital to include formularies and/or guidelines that assist physicians in their decision making. Integration with other hospital information technology systems including electronic patient records, pharmacy, laboratory, and other services provides the prescriber with all information necessary to develop and transmit an effective, error-free order. CPOE uses clinical decision support systems and links to hospital systems to generate prompts and alerts during the ordering session to notify of potential errors such as contra-indicated medications or routes or duplicate orders. Unlike other clinical decision support systems, CPOE is distinguished by the requirement that the prescribing physician is the primary user.

Though the vast majority of the literature related to CPOE focuses on medication ordering, assumed to have the greatest impact on improved patient safety, CPOE also encompasses other orders including those for laboratory, radiology, consults, ancillary services, admissions, discharges, etc. The focus of research to date has been on inpatient hospital settings, though reports of CPOE use in ambulatory and other settings are emerging.

Figure 1 shows how CPOE is positioned and integrated with a hospital's information technology systems. Rules may be embedded in various applications, such as the clinical data repository (CDR), to control duplicate testing, antibiotic or narcotic restrictions, or to promote formulary use.

¹ Making Health Care Safer: A Critical Analysis of Patient Safety Practices., Evidence Report/Technology Assessment, No. 43. AHRQ Publication No. 01-E058, July 2001, Agency for Health Care Research and Quality, Rockville, MD <http://www.ahrq.gov/clinic/ptsafety/>

² A Primer on Physician Order Entry. California HealthCare Foundation and First Consulting Group. September 2000.

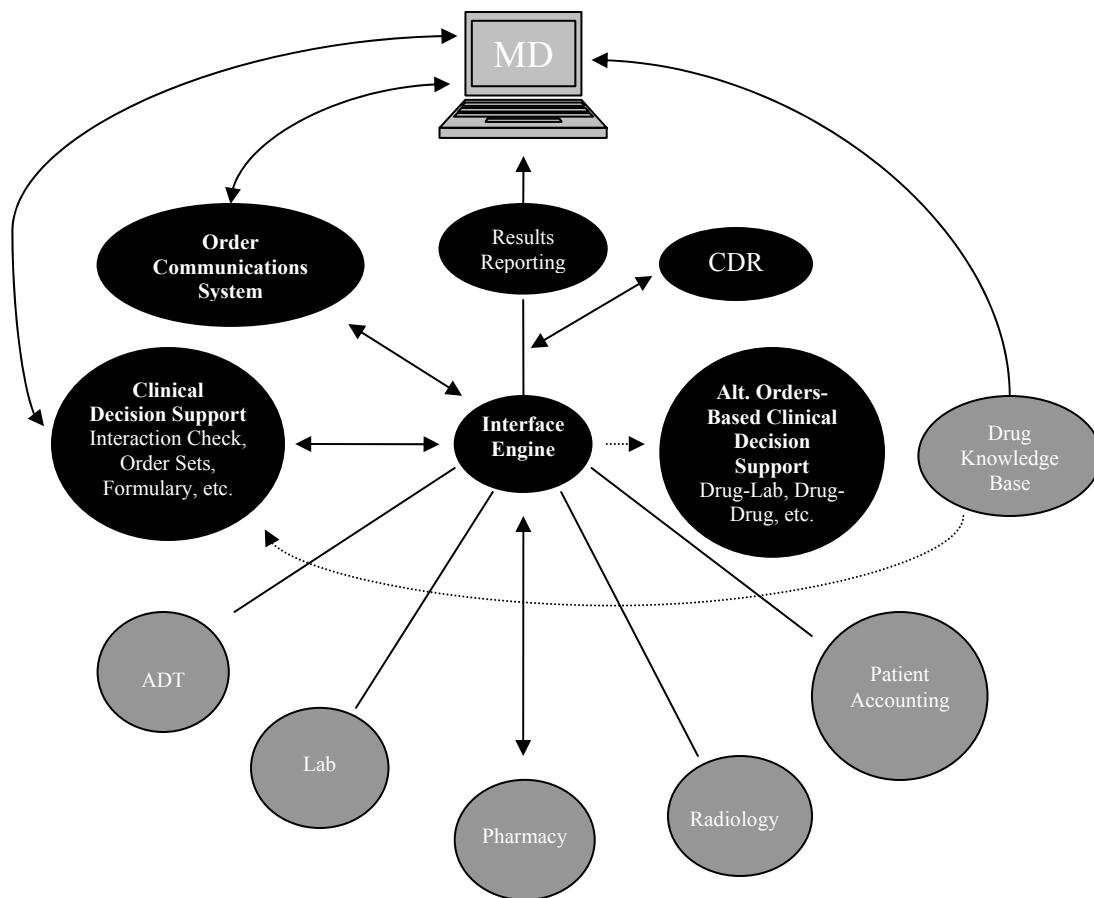


Figure 1. Overview of Ordering Information Architecture³

CPOE in the U.S.

Recent literature cites that between 5% and 9% of U.S. hospitals currently have CPOE systems in place.^{4,5} Of the thousand hospitals responding to the most recent Leapfrog hospital survey, only 4% had fully implemented CPOE systems; another 16% planned for implementation by 2006.⁶ Only seven of the 67 acute care hospitals in the Commonwealth of Massachusetts have CPOE systems in place.⁷ Another study reported that 15% of the 668 hospitals surveyed had fully or partially implemented a CPOE system.¹

³ Kilbridge, P, Classen, D, A Process Model of Inpatient Medication Management and Information Technology Interventions to Improve Patient Safety. 2001 Research Series Volume 1. First Consulting Group for VHA Inc.

⁴ Koppel, R. et al. Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors. *JAMA*. 2005; Vol. 293, No. 10, 1197-1203.

⁵ Ash, J, et al., Computerized physician order entry in U.S. hospitals: Results of a 2002 survey. *J Am Medical Information Association*. 2004; 11:95-99.

⁶ http://www.leapfroggroup.org/media/file/Leapfrog-Survey_Release-11-16-04.pdf Accessed 4/24/05.

⁷ Treatment Plan: High Tech Transfusion, Case Statement for Implementation of CPOE in all Massachusetts Hospitals, Massachusetts Technology Collaborative and First Consulting Group. Fall 2004.

CPOE in Maine

The Maine Health Management Coalition, through the Pathways to Excellence initiative, collects information about the use of CPOE systems in Maine hospitals via annual surveys developed by a team of Maine clinicians. In addition to assessing the extent to which Maine hospitals have implemented CPOE (percent of prescriptions entered and availability to all inpatients), the survey asks about details of certain functions. For example, hospitals report whether they check dose ranges for all patients, the manner in which drug-drug and allergy checks are made, and whether overrides are documented. Please refer to Appendix A for an excerpt of the survey relating to CPOE. The Maine Health Management Coalition synthesizes the responses and posts the results on its website, www.mhmc.info.

What CPOE is Not

There are a number of electronic and/or intelligent systems, designed to reduce medication errors, that are not CPOE systems.⁸ For instance, most hospitals have computerized applications in which other clinical staff enter physicians' orders electronically from physicians' written notes. These systems may have some rules-checking capabilities; however, they are primarily 'capture and transmit' systems, often referred to as order document management systems or transcribing systems.

Pharmacy systems with decision support software have proven effective at reducing medication errors, though they are not CPOE, as these systems generate reviews of orders after they have been initiated (by paper or electronically) by the prescriber.⁹

CPOE systems rely on interfaces with clinical decision support systems (CDSS) that supply logic, rules, and information about medications and interactions.¹⁰ CDSSs may be implemented without a CPOE. For example, the prescriber may research the drug for drug-drug interactions using a CDSS and then write a paper prescription and give it to the nurse for transcription.

CPOE Functions

In addition to 'home grown' CPOE systems, at least 13 vendors offer CPOE products that can be adapted and integrated into existing hospital information technology (HIT) systems.¹¹ Some products are modules that fit within an existing set of HIT products from the same vendor; others are products that 'wraparound' existing systems. It is important to appreciate the variation among CPOE products.

For example, basic CPOE systems may simply offer a selection menu of drug names and doses or predefined order sets. Other applications may limit field entries for dosage control while others provide default values and templates that offer more

⁸ Adubofour, K. et al., Strategies to Reduce Medication Errors in Ambulatory Practice. *Journal of the National Medical Association*. 2004. 96;1558:1564.

⁹ George, D., et al. The Challenge of Assessing Patient Safety in America's Hospitals. 2002. Protocare Sciences Report.

¹⁰ Metzger, J., et al. Clinical Decision Support: Finding the Right Path. September 2002. FCG.

¹¹ Metzger, J and Turisco, F., Computerized Physician Order Entry: A Look at the Vendor Marketplace and Getting Started. December 2001. First Consulting Group.

guidance. Pull down menus may provide definitions, routes or information about drug interactions. Some functions may be passive, requiring the prescriber to search for a particular field; other functions are active and automatically provide needed data. More advanced applications integrate electronic medical records (EMRs) with surveillance systems that alert the physician of changes in patient vital signs and other clinical status issues.

Variation in basic products is exacerbated by the manner in which each hospital chooses to operate its CPOE, or integrate it into the hospital's existing or developing IT systems, and to support it after implementation. For example, some hospitals do not require all physicians or all departments use the CPOE or they may allow prescribers to turn off some functions that physicians consider annoying.¹² This can be counter-productive; for the CPOE system to be effective at checking a new order against possible duplicate orders for the same patient, it is essential that all orders are entered into the system.

Recognizing variations in product sophistication and implementation, and noting that products and applications are being enhanced continuously, the critical features of CPOE to date appear to be:

- Interaction Checking
 - Drug-drug
 - Allergies – to drug or to a similar drug in same category
 - Drug-food
 - Drug-herbal medicine
- Checking for overlaps with another new or active order (same drug, class or combinations)
- Checking for overlaps with pending, conditional, standing, cascading, tapered, or structured orders
- Prompting for corollary orders – in the case when an intervention requires a subsequent or companion order to maintain the standard of care
- Prompting for sets of orders by diagnosis or condition (e.g., pre-post operative)
- Checking for contra-indicated medications
 - By route (oral, intravenous, intramuscular)
 - For patient's diagnosis
 - Relative to patient's laboratory results
 - Relative to patient's vital signs
 - Relative to pregnancy

¹² Metzger, J., Fortin, J. Computerized Physician Order Entry in Community Hospitals: Lessons from the Field. 2003. California HealthCare Foundation and First Consulting Group.

- Relative to radiology tests for patient (use of contrast medium, etc)
- Checking for dose calculations
 - Based on patient's weight, height and age or BSA (body surface area)
 - Based on patient's diagnosis
- Cost of care checking
 - Duplicate tests
 - Hospital or benefit formulary (if not already defaulted to the formulary)

Ancillary Functions

Overrides - CPOE systems also have an override function allowing free text entry of orders that can override system alerts and prompts. (Note: the use of overrides is addressed in the *Standards* section below).

Medication severity alerts – The hospital may set levels of severity alerting for specific medications.

Reports – Results reporting functions generally include basic results management and reporting that can be tailored to particular quality improvement initiatives.

Communications – Many CPOE systems have a section to record comments or notes of prescribers or other providers. There are also physician messaging functions referenced in some systems, some of which offer mobile wireless connections.

CPOE Functions and Patient Safety

CPOE is designed to be proactive, rather than reactive in reducing medical errors. Order checking (duplicate, dosage, allergy, contraindicated, patient history, etc) reduces potential errors that would occur if all relevant information were not available to the prescriber at the time of ordering. Given the dynamic and growing pharmaceutical marketplace, prompts providing information to the prescriber on specific drugs and their minimally effective dosage by diagnosis and patient attributes, can be valuable tools to prevent adverse drug events.

Below is a cross walk of Leape's major causes of medication errors with the features of specific technologies designed to address each cause.¹³ Note that in addition to CPOE systems, other technologies, used subsequent to the prescriber's order, are included. Specifically, after the prescriber issues the order via CPOE, the pharmacy information system would verify it and prepare the medication for administration with automated dispensing devices and tools (robots, bar coding, etc), followed by administration by nursing staff. The chart was developed by the California HealthCare Foundation.¹⁴

¹³ Leape, L., Bates, D. et al., Systems Analysis of Adverse Drug Events., *JAMA*. 1995;274:35-43.

¹⁴ Addressing Medication Errors in Hospitals: A Framework for Developing a Plan, July 2001.

Prepared for California HealthCare Foundation by Protocare Sciences and adapted from Leape, et al. Systems Analysis of Adverse Drug Events. *JAMA*. 1995;274:35-43.

Table 1. Medication Errors and Technologies to Prevent Them

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

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

Standards

National quality improvement and accreditation organizations have acknowledged the potential value of CPOE and related technologies in improving the quality of care. However, current standards are very broad and have not yet addressed the variation in structure, processes, implementation or specificity for outcomes.

A Massachusetts collaborative of hospitals, payers, and providers recently announced its initiative to implement CPOE in all 76 hospitals in that state. The Massachusetts Technology Collaborative's initial assessment finds that there are, "no clear specifications and standards regarding the capabilities and performance of CPOE systems or guidelines regarding best practices for installation and implementation."⁷ It has developed a preliminary set of critical requirements for acceptance, implementation, and performance that can be found in Appendix B. The collaborative will be refining these requirements and forming standards as they proceed with CPOE implementation. The Collaborative hopes to have standards completed this summer.

National Quality Forum (NQF)

In 2003 the National Quality Forum issued a consensus report listing 30 safe practices recommended for adoption by U.S. hospitals.¹⁵ Seven of those practices relate to medication administration and management including item 12, 'implementation of a computerized prescriber order entry system.' The NQF specifies that prescribers should enter hospital medication orders using an automated information management system that:

- Is linked to prescribing error prevention software;
- Enables the review of all new orders by a pharmacist before administration of the first dose of the medication;
- Permits the notation of all pertinent clinical information about the patient, including allergies, in one place;
- Categorizes medications into families to facilitate the checking of medications within classes and retains this information over time;
- Internally and automatically checks the performance of the information system;
- Requires prescribers to document the reasons for any override of an error prevention notice;

¹⁵ *Safe Practices for Better Health Care: A Consensus Report*. 2003. National Quality Forum.

- Performs dose range checks to prevent excessive doses from being inadvertently ordered and administered; and
- Distinguishes between different doses of the same medication used for multiple indications, including off-label uses.

These standards do not address the percentage threshold of prescriptions that should be used to deem the CPOE system effective. Neither does NQF indicate how the system would be tested to validate error detection, either actual errors or potential errors through its clinical decision processes. These are addressed to some extent in the following group's standards.

Leapfrog Group

CPOE is one of four categories included in the Leapfrog Group's hospital safety survey.¹⁶ The Leapfrog CPOE standard requires:

- 1) that physicians enter hospital medication orders via a computer system linked to error-prevention software,
- 2) the hospital can demonstrate (via a test under development by First Consulting Group and the Institute for Safe Medication Practices) that the system can intercept at least 50% of common serious prescribing errors, and
- 3) documented acknowledgement by the prescribing physician of the interception prior to any override.¹⁷

A fully implemented CPOE is one in which at least 75% of all medication orders are entered via CPOE. Hospitals may receive either a 'Good Early Stage Effort' or 'Good Progress' rating prior to complete implementation of CPOE by having implemented a hospital-wide electronic medical records system or a results reporting system that handles 90% of all laboratory and radiology results electronically, to demonstrate the hospital's commitment toward developing a CPOE.

The Leapfrog hospital survey also asks whether the hospital has a 'physician champion' to spearhead the CPOE effort, whether a dedicated budget has been approved and, for hospitals with more than 200 beds, whether an in-house pharmacist is available 24 hours per day, seven days per week to review orders prior to dispensing.

Note that the test in item 2 above is expected to assess only the adequacy of the CPOE's decision support system, not the actual effectiveness of the system in terms of adverse drug events (ADEs) the system prevented or those that occurred.

¹⁶ The other categories are ICU physician staffing, evidence-based hospital referrals, and the Leapfrog quality index which is comprised of the 27 remaining National Quality Forum's safe practice areas.

¹⁷ Leapfrog Group Hospital Quality and Safety Survey (version 3.1), March 16, 2005. http://www.leapfroggroup.org/for_hospitals. Accessed April 23, 2005.

Joint Commission on Accreditation of Healthcare Organizations

In its recent white paper addressing patient safety, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) indicated ways in which CPOE could be advanced; however, it fell short of identifying standards or initiating requirements. Among ways to strengthen adoption of CPOE, JCAHO cited physician leadership, system support, environmental integration, and training.¹⁸ The Commission also suggests that financial and performance incentives would speed implementation of CPOE and similar information technology systems.

JCAHO previously strengthened its medication management standards in 2004 to require inclusion of a diagnosis, pharmacist review of all prescriptions, and protocols addressing incomplete orders, among other issues. By January 2006, JCAHO will require hospitals to capture and transmit to each service providing care within or out of the facility, a complete list of each patient's medications. It currently has a proposal to mandate medication bar code scanning by 2007.

United States Pharmacopeia (USP)

This organization sets standards for a wide variety of medication-related issues, some of which it also enforces for the Food and Drug Administration. With the Institute for Safe Medication Practices, it operates a Medication Errors Reporting (MER) Program. USP uses results from MEDMARX, a national, medication error database with voluntary medication error reports from over 700 healthcare facilities, to study and assess ADE causes. The USP's Safe Medication Use Expert Committee, a diverse public, private, academic body is currently working on a set of rules for decision support of CPOE systems. No timeline has been set for release of these rules.

¹⁸ *Health Care at the Crossroads: Strategies for Improving the Medical Liability System and Preventing Patient Injury*. 2005. Joint Commission on Accreditation of Healthcare Organizations.

Review of the Literature

The Problem

Drug knowledge dissemination, dose and identity checking, and availability of patient information accounted for 52% of all medication-related errors identified in a study involving 4,031 non-obstetric adult admissions in 11 medical and surgical units of two tertiary care hospitals over a six month period in 1993.^{13, 19} The authors classified adverse drug events (ADE) and potential ADEs by proximal causes and system failures and found 26 major system failures for the 334 errors, of which 29% were related to physicians' drug knowledge, 12% to dose and identity checking, and 11% to patient information availability. Of all ADEs in this study, 1% were fatal, 12% life threatening, 30% serious, and 57% significant; 42% of the life threatening and serious ADEs were determined to be preventable. Of particular note is that more than half (56%) of the errors occurred at ordering phase.

A subsequent study with a similar design (prospective cohort study of all admissions to two teaching hospitals during a six month period in 1999) found similar preventable error rates for pediatric patients.²⁰ However, the potential ADE rate was three times as high for this population. In this study 74% of the medication errors (N=616) occurred at physician ordering. Error types included dosing, 28%, route, 18%, and frequency, 9%.

The Promising Solution

In a seminal study, often referenced by promoters of CPOEs, Bates, Leape, and colleagues evaluated the efficacy of CPOE interventions for preventing non-intercepted serious medication errors in a randomized sample in six medical and surgical units of the Brigham and Women's Hospital, a 700 bed tertiary care academic hospital in Boston.²¹ Their study concluded that use of physician computer order entry decreased the rate of non-intercepted serious medication errors by 55%. Another category of ADE, non-intercepted potential ADEs (including life-threatening, serious and significant), decreased 84%. When prescribers selected options from menus, were advised by prompts and other attributes of the Brigham's home grown CPOE system, dosing errors decreased by 23%, allergy errors reduced by 56%, and drug-drug interaction errors fell 40%. Although all order-related errors (dispensing, administration, etc) also fell as a result of the intervention, other authors point out that the 17% decrease of actual serious ADEs was not statistically significant.²²

¹⁹ Bates, D, et al., Incidence of Adverse Drug Events and Potential Adverse Drug Events, Implications for Prevention. *JAMA*. 1995;274:29-34.

²⁰ Kaushal, R, Bates, D., Medication Errors and Adverse Drug Events in Pediatric Inpatients. *JAMA*. 2001;285:2114-2120.

²¹ Bates, D, Leape, L, et al, Effect of Computerized Physician Order Entry and a Team Intervention on Prevention of Serious Medication Errors. *JAMA*. 1998;280:1311-1316.

²² Berger, R, Kichak, J, Computerized Physician Order Entry: Helpful or Harmful? *J Am Med Inform Assoc*. 2004; 11:100-103.

The IOM and AHRQ point to the potential of CPOE and CDSS systems over paper systems for improving patient safety by reducing handwriting and dose specification errors, linking to interaction and contra indication warnings, and avoiding drug name confusion.²³ They also caution that user-system interface is an important element to CPOE success and that systems cannot prevent errors if critical information is not included within the CPOE system.

Reports and case studies from early adopters of CPOE describe successful systems in terms of cost savings and error reduction. Many are couched in terms of “lessons learned” after trial and error during the implementation and training phase.^{12, 24} In its review of five years accumulation of medication error data in its MEDMARX database, USP found that 99% of errors occurring in CPOE systems did not reach or harm patients.²⁵

Unintended Consequences

The debate on the efficacy of CPOE is a dynamic one. In a recent JAMA article, Koppel identified 22 types of medication errors facilitated through the use of a CPOE system in use at a 750 bed teaching hospital.⁴ The next day the Leapfrog Group posted a response to the study, quoting national patient safety expert David Bates in support of CPOEs, noting the Koppel study did not identify error rates prior to CPOE system installation and only one system was studied.²⁶

It is important to understand the Koppel study in context. The author notes that though the CPOE system studied is based on a product with a 60% market share nationally; it had been customized by the hospital (as is the case with most systems) and the results may not be widely generalizable. He further notes that an increase in medication errors was an unanticipated finding, resulting from extensive quantitative analysis, surveys and focus groups of house staff. The work ultimately suggests that hospitals use a cautionary approach to implementing any new system and plan for continuous revisions and quality improvement to avoid introducing new errors while eliminating others. It is interesting to note that Bates authored a study of an assessment of a CPOE system that resulted in an initial increase of ADEs prior to system refinement and subsequent decrease in ADE rates.²⁷

More Than Technology

Focusing on organizational factors, rather than relying solely on technology to solve problems is also a theme in a JAMA editorial, subtitled, *Still Waiting for Godot*.²⁸

²³ Institute of Medicine. *To Err Is Human*. Washington, DC, National Academy Press. 1999.

²⁴ Dexter, P. et al., Inpatient Computer-Based Standing Orders vs Physician Reminders to Increase Influenza and Pneumococcal Vaccination Rates. *JAMA*. 2004;292;2366:2371.

²⁵ US Pharmacopeia website: <http://www.usp.org/>. Accessed May 8, 2005.

²⁶ Leapfrog Responds to University of Pennsylvania Study on CPOE Errors. www.leapfroggroup.org.

²⁷ Bates, D, et al., The Impact of Computerized Physician Order Entry on Medication Error Prevention. *J Am Med Inform Assoc*. 1999;6:313-321.

²⁸ Wears, R, Berg, M., Computer Technology and Clinical Work, Still Waiting for Godot, *JAMA*. March 9, 2005. Vol. 293, No. 10 1261-1263.

Physicians Wears and Berg note that information systems should not be developed in isolation, evaluated by their creators, or imposed on ‘one of the most complex enterprises in modern society.’ They suggest that information technology be tailored to the front line workers (physicians) and their environment and guiding organizational change is essential to the introduction of technological tools.

These sentiments are echoed in reports and findings from recent studies that suggest that when COPE systems are treated as another IT project, imposed on the work environment without sufficient buy-in or training, they may fall short of achieving their full potential or they may also contribute to errors.^{2, 4, 12, 29, 30} Because CPOE is a fundamental redesign of the physician’s work flow that requires physician leadership and staff training at all levels of the hospital, it can be a time-consuming process during system design, implementation, training, and evaluation, and refinement. Only after an effectively operating CPOE is mature, does it provide increased efficiency in the form of reduced time for re-checking, clarifying, or modifying orders, as is often the case with paper orders.

Relationship Between Champions and Developers

Berger, characterizing the objective data on CPOE efficacy as scant, questions the motives of the Leapfrog Group’s efforts at promoting the use of CPOEs, noting that its corporate members would benefit financially from their use.³¹

Provider Performance as a Proxy for Patient Outcomes?

Dr. Garg, after reviewing the results of 100 controlled trials using diverse computerized clinical decision support systems (CDSS) including CPOE, concluded that, “Many CDSSs improve practitioner performance...to date, the effects on patient outcomes remain understudied and, when studied, inconsistent.”³² His team assessed practitioner performance and patient outcomes from a variety of systems including those for diagnosis, prevention, disease management, drug dosing, and prescribing. While only 13% of the 52 studies indicated improved patient outcomes, 64% of the 97 studies found that practitioner performance was improved as a result of the CDSS. Specifically, 76% (n=21) of the studies of reminder systems and 66% (n=29) of the studies of drug-dosing or prescribing systems showed improved provider performance.

Improvement in outcomes was defined as a statistically significant positive effect on at least 50% of outcomes measured for each study. Practitioner improvement included various definitions depending upon the particular study; some examples are adherence to recommendations, inappropriate prescriptions per 1000 visits, discontinuation of potentially inappropriate prescriptions and proportion of patients within therapeutic

²⁹ Levick, D., O’Brien, D, CPOE is Much More than Computers. *Physician Executive*. 12/2003, 48-52.

³⁰ Poon, E, et al. Overcoming Barriers to Adopting and Implementing Computerized Physician Order Entry Systems in US Hospitals. *Health Affairs*, Vol. 23 Issue 4, 184-190.

³¹ Berger, R, Kichak, J, Computerized Physician Order Entry: Helpful or Harmful? *J Am Med Inform Assoc*. 2004; 11:100-103.

³² Garg, A, et al. Effects of Computerized Clinical Decision Support Systems on Practitioner Performance and Patient Outcomes, A Systematic Review. *JAMA*. 2005; 293:1223-1238.

range. Patient outcomes, a range of adverse drug events, were defined variously as time to hospital discharge, mortality, bleeding complications or, specific to the particular drug in each study. Dr. Garg suggests that, until sufficient randomized controlled trials with adequate statistical power are available to gauge effects in patient outcomes, it may be reasonable to evaluate practitioner performance outcomes when evaluating CDSS or CPOE effectiveness.

All Systems are Not Created Equal

Few academic papers discuss the technological details of the CPOE systems that are the underpinnings of the studies. Most report that their results may not be generalizable due to the nature of their system, stage of implementation, or because of the manner of tailoring to the hospital's other information systems. Bobb, in her study of a 700 bed academic medical center in Chicago, discusses variation in effects of different systems, concluding that the percent of errors caught or missed depends on the intelligence of the system.³³ Some variations in the study include whether the system:

- warns the prescriber of a problem vs. those that incorporate numerous parameters at the time of order entry,
- allows duplicate checking features to be turned off,
- allows for processing of incomplete orders, or
- is linked to complete medication history data.

That study identified 62 errors per 1000 medication orders, of which 30% were clinically significant and included incorrect dose, medication knowledge, and anti-infective medication errors. The study team estimates that 20% of dosing errors would likely be prevented with CPOE; however, another 50% - a total of 70% of dosing errors - would possibly be prevented, depending upon the sophistication of the system.

³³ Bobb, A. et al., The Epidemiology of Prescribing Errors: The Potential Impact of Computerized Prescriber Order Entry. *Arch Intern Med.* 2004;164:785-792.

Cautions and Considerations for CPOE Implementation, Standard Setting, and Evaluation

USP analyzed five years of medication errors reported in its MEDMARX system to understand errors associated with CPOE. Ironically, common errors included confusion with abbreviations (21.6% of screen display errors) and calculation errors (20.9% of programming/rules errors), functions that should be easily controlled in any standard computer.³⁴ Bobb points to a variation in reduced dosing errors from 20% to 70%, depending upon the CPOE system in place.³³ These findings underscore the variation in CPOE systems and the lack of comprehensive standards to support them.

Implementing any new technology should be accompanied by evaluation and refinement to avoid introducing new errors. Yet the system in which Koppel identified 22 CPOE-facilitated errors had been in place for eight years and, though it was tailored to that hospital's environment, it is a relatively common product.⁴ We do not know if it conformed to existing CPOE standards (Leapfrog and NQF), but it may have. It may be useful to review some of those errors and their causes to consider the level of detail needed for standards or best practice guidelines that might address them. The errors below appear to stem from fragmentation of processes, lack of prescriber training on the CPOE system, and confusing displays of information.

Table 2. Summary of Errors and Causes from Study of Errors Facilitated by CPOE⁴

Error	Cause
Wrong patient	Confusing logon/logoff procedures that make it unclear whether a prescriber is ordering for his patient or the patient of the prescriber who had previously used the computer
	Scrolling through many screens to view a patient's medication history without the patient's name on display
	Medications delivered to wrong room when system is down (for maintenance or a system crash) and patient has moved
Wrong patient/ wrong medication	Small fonts make it difficult to select the correct patient's name/ medication
Dose errors	Dosages are based on units stocked in the pharmacy, rather than by minimally effective dose
New medication /Dose errors	Ambiguity with ordering a new medication or adjusting a dosage of a current medication without canceling the current order
Procedure- medication link	No link to notify prescriber that the procedure (for which the medication would be ordered) was cancelled by another physician

³⁴ Santell, J, Webber, R, Bates, D., Computer Related Errors: What Every Pharmacist Should Know. (Presentation). USP Center for the Advancement of Patient Safety . December 9, 2004. <http://www.usp.org/pdf/EN/patientSafety/slideShows2004-12-09.pdf>. Accessed May 8, 2005.

Error	Cause
Allergy Interaction	System provides feedback on allergies only after the medications are ordered, requiring start, stop, re-start process
Duplications	Failure to chart 'now' and 'give as needed' orders at handoffs
Duplications/ conflicting	System does not display all information; pharmacists must clarify orders for drug interaction and life time limit with prescribers
Gaps in Orders	Confusing system for identifying date and time of medication order administration for late in day orders
	Physicians must re-activate each suspended order for post op patients
	Reminder system not congruent with antibiotic sticker system in use on patients' charts in that hospital
	Non-formulary medications require multiple steps and start, re-start processes
Diluent errors	System does not check for diluents/antibiotic interactions

Standard setting organizations have focused on broad CPOE functions, but they have not yet developed specifications for even basic best practice CPOE processes. For example, dosage displays may require the prescriber to enter a dosage into a fill-in-the-blank field, to which the system might respond with a reactive alert for the prescriber to consider. Other systems may default to a minimum effective dose that the prescriber could accept or override if needed or, as seen above, some hospitals may choose to have the display default to units stored in the pharmacy.

Some of the errors in Koppel's study appear to have easily correctable causes. Whether they are vendor products or homegrown, systems could be required to show patient names on each screen, display all medication history concisely, and ensure secure logon and logoff procedures.

Implementing systems tailored to accommodate each hospital's needs may present the biggest challenge when developing standards. For example, in the Koppel study, the hospital had a tandem paper reminder system for antibiotic medications that was not replicated or referenced in the electronic system. Neither the cause or the resulting error would be identified by a clinical decision support system test (being developed by Leapfrog), but only from an evaluation of errors and root cause analysis.

The best designed, configured, and implemented system still requires staff training in order to be effective. The Koppel study highlighted a lack of prescriber knowledge about basic operations of the system that clinicians were required to use. There has been no discussion about standards addressing the issue of user training.

By reviewing the Koppel errors, we do not imply they are an exhaustive list of potential errors that may be caused by CPOE or that they should be the primary focus of standard development, but merely to illustrate the variation in processes in a mature CPOE system. Many user complaints cited in the literature refer fleetingly to nuisance

alerts, processes that are generally not intuitive or that require start/stop/re-start processes. Koppel's errors and causes are useful due to their detail and context.

Multiple vendors, each with multiple products, implemented and tailored to each environment, pose a challenge to any organization seeking to implement a system, strengthen standards, or identify evaluation criteria. Beyond current broad standards, helpful suggestions and recommendations from industry consulting organizations and 'lessons learned' from early adopters, there is little else to guide organizations in the details of system design, implementation, and performance measurement.³⁵

Supporters of CPOE generally suggest proof of CPOE effectiveness by providing evidence of reductions in medication error rates and costs; they also provide insight into the configuration of the system to the hospitals' needs.^{21, 24, 27, 36} The former should be a relatively discrete exercise with comparable results, while the latter is dependant on each hospital's specific requirements and practices. Until such time that comprehensive standards are developed on which to evaluate CPOE, perhaps a range of error reduction outcomes would be appropriate measures.

³⁵ See Appendix B.

³⁶ Raschke, R, et al. A Computer Alert System to Prevent Injury from Adverse Drug Events. *JAMA*. 1998;280:1317:1320.

Financial Considerations

Cost of Errors

Financial implications of medication errors has also been a topic in the literature. The First Consulting Group uses the rate of \$6,856 (2004 dollars) for each preventable ADE when estimating cost savings.⁷ The amount originates from a 1997 study by Bates, in which the costs of increased hospital stays, resulting from each preventable ADE, was calculated for a study of medication errors in two hospitals.³⁷ The extrapolated costs, attributable to all ADEs for a 700 bed teaching hospital, were estimated in 1997 to be \$5.6 million annually, with \$2.8 million annually for all preventable ADEs. In another study, a savings of \$26 per patient was shown in fifty percent of emergency department visits by patients with available current clinical data.³⁸

Cost of Implementing a CPOE System

Of the various technologies listed in Table 1, CPOE may be the most expensive and difficult to implement given integration needs with other systems, training, and buy-in of physicians and staff. Assessing the costs and concomitant benefits depends on hospital size and current implementation (and acceptance) of hospital IT systems that are fundamental to building a CPOE. CPOE is available from standard HIT vendors as one module of a hospital information system and designed to function with compatible technologies (EMR, pharmacy, laboratory systems, etc) from the same vendor. If a hospital already has a suite of information technology products in place, adding one more from the same vendor would be less costly than building one from the ground up.

Alternatively, some vendors provide CPOE products that ‘wrap around’ home grown or other existing information systems. These would require more extensive interfacing to connect to the requisite existing systems. Regardless of the approach, considerable time for development, installation, and testing is required as well as software, hardware, and process re-engineering.

CPOE has largely been implemented in tertiary care, urban teaching hospitals; consequently, information regarding costs and administration is primarily focused in that environment. However, in a recent study assessing the feasibility of implementing CPOE in a rural state, the authors report estimates from CPOE vendors for a range of hospitals.³⁹ Table 3 shows high and low cost estimates depending upon the current level of supporting information technology systems in place.

³⁷ Bates, D, et al., The Costs of Adverse Drug Events in Hospitalized Patients, *JAMA*. 1997;227:307:311.

³⁸ Overhage, M, A Randomized Controlled Trial of Clinical Information Shared from Another Institution. *Annals of Emergency Medicine*. January 2002.

³⁹ Ohsfeldt, R, et al. Implementation of Hospital Computerized Physician Order Entry Systems in a Rural State: Feasibility and Financial Impact. *J Am Med Inform Assoc*. 2005;12:20-27.

Table 3. Estimated Costs of CPOE Implementation in a Rural State³⁹

	Median N of Beds	Low Estimate	High Estimate
Urban Hospital	282	\$1.9 M	\$4.4 M
Rural Referral Hospital	212	\$1.9 M	\$3.2 M
Rural Hospital	62	\$1.3 M	\$2.1 M
Critical Access Hospital	45	\$1.3 M	\$2.1 M

Ongoing operating costs range between \$238,000 and \$889,000 annually.

To determine implementation feasibility the authors applied a simulation model to all hospitals in Iowa, admittedly using crude estimates of depreciation, interest rates, and third party payments. They conclude that small patient volumes would not generate reimbursements sufficient to fund increased operating costs resulting from CPOE in small hospitals. However, the authors suggest that for urban hospitals and rural referral hospitals, the substantial cost impact of a CPOE could be offset by patient care cost savings and increased revenues.

What is on the Horizon?

To date most studies of costs, error reduction, and quality improvement resulted from early adopters of largely homegrown CPOE systems. In recent years new vendors have moved into the marketplace and CPOE systems are taking hold, albeit slowly. In the coming years we should expect to see quality improvement study results from systems implemented after 2000. Hopefully, they will include more specificity on CPOE attributes, whether technological or organizational, that most affect patient safety.

In recent years studies using CPOE in ambulatory settings, emergency departments, and other non-tertiary care settings have emerged.^{12, 38, 40} As implementation expands, similar reports from other care settings should provide useful lessons.

Next generation CPOE systems are expected to have greater device integration with beepers, handheld devices, and workstations in more locations (practices, home, in addition to hospitals) via wireless connections and offering more flexibility and

⁴⁰ Karow, H. Creating a Culture of Medication Administration Safety: Laying the Foundation for Computerized Provider Order Entry. *The Joint Commission Journal*. 2002.

fluidity.⁴¹ Greater access via the web and at the bedside is expected to improve integration into physician workflow.⁴²

Standard Setting Organizations

The Leapfrog Group admits their initiative to propel CPOE has had a slower effect than expected due to the ‘inability of the group to generate a substantial business case for quality’.⁴³ Though it is re-tooling its effort to focus more on health plans and to broaden quality measures, the continued importance placed on CPOE remains to be seen. In any case, the evaluation tool to assess rates of medication error interceptions in CPOE systems should be available soon. Results from hospitals’ use of Leapfrog’s tool would subsequently be available in hospital survey results in the future.

JCAHO will release a report entitled, “Using Technology to Improve Medication Safety” in July 2005.⁴⁴ This work will address the strengths and weaknesses of CPOE and other medication safety devices such as medication bar coding, radio frequency identification (RFID), automated dispensing devices, robotics, and electronic medical records.

U.S. Pharmacopeia’s Safe Medication Use Expert Committee is developing a set of rules for CPOE decision support using its MEDMARX national database. The time frame for the report is unclear.

Information on Use and Experience

The Maine Health Management Coalition MHMC has collected what appear to be very useful information in assessing the extent to which CPOE used in Maine. Results of implementation levels and specific error-checking processes have been combined to produce synthesized reports on overall medication safety that are posted on the MHMC website. MHMC intends to strengthen the survey further and repeat it in the coming year. Perhaps more detailed findings will be available in the future.

Finally, as the Commonwealth of Massachusetts progresses with its \$210M initiative to implement CPOE state-wide in all hospitals, we should expect results from that experience to be instructive to other states.⁷ Massachusetts’ smaller acute care hospitals and its small rural and critical access hospitals, similar to those in Maine, are included in that initiative. The implementing organization has reported that guidelines for implementation are lacking; it is currently in the process of developing detailed standards which they hope to complete soon and make publicly available.

⁴¹ Robb, R., Presentation: CPOE, the Next Generation at CPOE 2005 and Beyond: Is your Pharmacy Prepared?, 2004 Clinical Meeting of the American Society of Health System Pharmacists.

⁴² Handler, J, et al Computerized Physician Order Entry and Online Decision Support. *Academic Emergency Medicine*, 2004. Vol. 11, No. 11, 1135-1141.

⁴³ Galvin. R. Delbanco, S., et al. From the Field: Has the Leapfrog Group Had an Impact on the Health Care Market? *Health Affairs*. 2005 Vol. 24, Number 1.

⁴⁴ <http://www.jcrinc.com/publications.asp?durki=9691>. Accessed 5/8/05.

Appendix A: Maine Health Management Coalition Patient Safety Initiative Phase III Survey Items Relating to CPOE

I. Medication Order Safety

Computerized prescriber order entry systems (CPOE) have been demonstrated to be an effective means of preventing medical errors. Computerized rules-based decision support systems that support order screening by pharmacists and nurses are also an effective means of minimizing medication errors.

A. Has your hospital fully or partially implemented a computerized prescriber order entry (CPOE) system? 1. Yes 2. No

B. Does your hospital have a pharmacist available on site or continuously available via remote computer access (not simply on-call) 24 hours a day / 7 days a week?
1. Yes 2. No

IF YOUR HOSPITAL HAS NOT IMPLEMENTED A CPOE SYSTEM, PROCEED TO QUESTION I D

C. Your hospital has fully or partially implemented a computerized prescriber medication order entry system that:

1. Automatically screens and provides prescriber alerts for:

a. Allergies

Patient allergy information is visible to prescribers on all medication order entry screens and the CPOE system automatically screens orders at the time of prescriber order entry against allergy information to alert prescribers and requires electronic documentation (not simply acknowledgement) to justify override.

Patient allergy information is visible to prescribers on all medication order entry screens and the CPOE system automatically screens orders at the time of prescriber order entry against allergy information to alert prescribers but overrides do not require electronic documentation (not simply acknowledgement) to justify override.

CPOE system does not automatically screen for allergies.

b. Potential drug-drug interactions

Potential drug-drug interaction alerts are visible to prescribers on all medication order entry screens at the time of order entry and the system requires electronic documentation (not simply acknowledgement) to justify override.

Potential drug-drug interaction alerts are not visible to prescribers on all medication order entry screens at the time of order entry or overrides do not require electronic documentation (not simply acknowledgement) to justify override.

CPOE system does not automatically screen for potential drug-drug interactions.

c. Therapeutic duplication
Therapeutic duplication alerts are visible to prescribers on all medication order entry screens at the time of prescriber order entry and the system requires electronic documentation (not simply acknowledgement) to justify override.

Therapeutic duplication alert is not available on all medication order entry screens or overrides do not require electronic documentation (not simply acknowledgement) to justify override.

CPOE system does not automatically screen for therapeutic duplication.

d. Appropriateness of dose range

CPOE system automatically screens for appropriateness of dose range information for, at a minimum, all orders for neonatal and pediatric patients, patients with impaired renal function, and patients receiving antineoplastics and alerts prescribers at the time of order entry and requires electronic documentation (not simply acknowledgement) to justify override.

CPOE system automatically screens for appropriateness of some dose range information but not for all orders for neonatal and pediatric patients, patients with impaired renal function, and patients receiving antineoplastics and alerts prescribers at the time of order entry and requires electronic documentation (not simply acknowledgement) to justify override.

CPOE system does not automatically screen for appropriateness of dose range for any of the above high-risk categories or does not require electronic documentation (not simply acknowledgement) to justify override.

2. Is available in all inpatient areas of the hospital.

the technology to permit direct prescriber medication order entry is in service for $\geq 75\%$ of available⁴⁷ inpatient beds.

the technology to permit direct prescriber medication order entry is in service for $\geq 50\%$ but $<74\%$ of available inpatient beds.

technology to permit direct prescriber medication order entry is in service for $\leq 49\%$ of available inpatient beds.

3. Is routinely used by prescribers to directly enter medication orders for patients in both inpatient and outpatient areas for which CPOE is available.

the technology to permit direct prescriber medication order entry is utilized by prescribers to enter $\geq 75\%$ of medication orders.

the technology to permit direct prescriber medication order entry is utilized by prescribers to enter $\geq 50\%$ but $\leq 74\%$ of medication orders.

technologies to permit direct prescriber medication order entry is utilized by prescribers to enter $<50\%$ of medication orders.

4. Requires regular review of all prescriber overrides

- representatives of the medical staff regularly review prescriber overrides, through a defined process, and there is a defined process to link failure of prescribers to follow safe medication ordering policies with their medical staff reappointment review process.
- representatives of the medical staff regularly review prescriber overrides, through a defined process, but there is no defined process to link failure of prescribers to follow safe medication ordering policies with their medical staff reappointment review process.
- representatives of the medical staff do not regularly review prescriber overrides through a defined process.

If the technology to permit direct prescriber medication order entry is in service for <75% of all available inpatient beds,

OR

If utilization in areas where CPOE is available is < 50%

OR

If your hospital does not have a CPOE system

PROCEED TO QUESTION I.D

Where computerized prescriber order entry systems (CPOE) are not available, the establishment of safe medication ordering policies and procedures have been demonstrated to be an effective means of preventing medication errors.

If your hospital has a pharmacist available on-site or continuously available via remote computer access (not simply on-call) 24 hours/day 7/days a week, answer question I.D.1 only.

If your hospital does not have a pharmacist available on-site or continuously available via remote computer access (not simply on-call) 24 hours/day 7/days a week, answer questions I.D.1 and I.D.2.

I D. Your hospital has not fully implemented a computerized prescriber medication order entry system, but has established safe medication ordering policies and procedures such that:

1. When a pharmacist is available on site or continuously available via remote computer access (not simply on-call), medication orders are routinely screened by a pharmacist, prior to the administration of the first dose, through an automated review*, including all medications taken from floor stock or “non-profiled” automated dispensing units.

Exemptions from pharmacist review of first dose medication orders include:

- *Situations or areas in which a physician or practitioner licensed to prescribe the medication performs or observes the ordering, dispensing, and administration of the drug and is physically present to monitor and respond to adverse reactions, e.g., emergency department, special procedure areas, labor & delivery, endoscopy.*

- *Emergency situations where the clinical status of the patient would be significantly compromised by the delay that would result from a pharmacist's review.*
- an audit** has been completed within the past 18 months that demonstrated that a minimum of 98% of first dose orders, excluding exempted areas and situations, had been reviewed by a pharmacist prior to administration of the first dose.
- an audit has been completed within the past 18 months that demonstrated that between 90% and 97% of first dose orders, excluding exempted areas and situations, had been reviewed by a pharmacist prior to administration of the first dose.
- an audit completed within the past 18 months that demonstrated that between 80% and 90% of first dose orders, excluding exempted areas and situations, had been reviewed by a pharmacist prior to administration of the first dose.

2. The Pharmacist uses an automated system of order screening that screens the new order against a computerized database that includes a listing of the patient's medications and other patient parameters so that: (check all that apply)

- Patient allergy information is visible to pharmacists on all medication order entry screens and the system automatically screens orders allergy information to alert the pharmacist.
- Potential drug-drug interaction alerts are visible to pharmacists on all medication order entry screens at the time of order entry.
- Therapeutic duplication alerts are visible to pharmacists on all medication order entry screens at the time of order entry
- The system screens for appropriateness of dose range information for, at a minimum, all orders for neonatal and pediatric patients, patients with impaired renal function, and patients receiving antineoplastics and alerts the pharmacist at the time of order entry

3. When a pharmacist is not available on site or not continuously available via remote computer access (not simply on-call), an automated review* is performed by a registered nurse for drug allergies, drug interactions, therapeutic duplications and dosing appropriateness for 98% of medication orders prior to the administration of the first dose, including all medications taken from floor stock or "non-profiled" automated dispensing units.

Exemptions from RN automated review of first dose medication orders include:

- *Situations in which a physician or practitioner licensed to prescribe the medication performs or observes the ordering, dispensing, and administration of the drug and is physically present to monitor and respond to adverse reactions, e.g., emergency department, special procedure areas, labor & delivery, endoscopy.*
- *Emergency situations where the clinical status of the patient would be significantly compromised by the delay that would result from an RN review.*

- an audit** has been completed within the past 18 months that demonstrated that a minimum of 98% of first dose orders, excluding exempted areas and situations, have undergone an automated review by a registered nurse with demonstrated competency in the medication review process prior to administration of the first dose.
- an audit has been completed within the past 18 months that demonstrated that between 91% and 97% of first dose orders, excluding exempted areas and situations, have undergone an automated review by a registered nurse with demonstrated competency in the medication review process prior to administration of the first dose.
- an audit has been completed within the past 18 months that demonstrated that between 80% and 90% of first dose orders, excluding exempted areas and situations, have undergone an automated review by a registered nurse with demonstrated competency in the medication review process prior to administration of the first dose.

ADDITIONAL CPOE / MEDICATION SAFETY INFORMATION

Please assist the Maine Health Management Coalition's effort to determine the extent of the effort in Maine's hospitals to consider the implementation of CPOE systems. Your response to these questions in section II will not be scored as part of this survey and will be used to share information among participating hospitals and MHMC members only. This information will not be publicly released.

II. CPOE Planning

A. If your hospital does not have a CPOE system installed, please indicate your current stage in planning and/or implementation.

1. Planning for CPOE
2. Currently selecting CPOE system (at a minimum, RFP has been released)
3. Currently implementing a CPOE system
4. None of the above

B. Does your organization have a written strategy for implementing CPOE?

1. Yes 2. No

C. Has your organization created a defined time line and launched a CPOE project?

1. Yes 2. No

D. What is the date by which your hospital expects to implement CPOE in all inpatient areas?

Date: _____

E. Has your hospital's Board approved a dedicated budget for CPOE for the latest fiscal year for which it approved a final budget?

1. Yes 2. No

F. Do you have an identified physician champion who is leading the CPOE initiative at your hospital?

1. Yes 2. No

G. Pharmacist availability:

1. How many hours per day does your hospital have a pharmacist on duty at the hospital?
2. How many hours per day does your hospital have a pharmacist continuously available with remote computer access to the pharmacy information system?
3. How many hours per day is your hospital without continuous pharmacist coverage?***

** An “automated review” is one in which rules-based technology is used to screen the order electronically as opposed to manually. Automated reviews must screen the medication order against the patient profile (including age, sex, height, weight, allergies, and current medication profile, at a minimum. Automated reviews do not include the use of electronic drug reference databases that require interpretation by the practitioner.*

*** An “audit” must include a statistically valid (95% confidence level), random sample of first dose orders during the audit period.*

**** A pharmacist who is “on-call” with or without remote access into the hospital’s pharmacy information system does not constitute a “pharmacist on duty” or a “pharmacist continuously available”.*

Appendix B: Requirements Used by the Massachusetts Technology Collaborative

Critical Requirements for CPOE Acceptance, Implementation, and Performance from the Massachusetts Technology Collaborative and First Consulting Group's report Treatment Plan: High Tech Transfusion A Case Statement for Implementation of CPOE in all Massachusetts Hospitals, Fall 2004.

A. Critical CPOE Requirements for Physician Acceptance		
Requirement	Description	Implication
1. Design of order screens and data entry that align with how physicians think about and write orders. Complex medication orders such as sliding scale and IVs with customized admixtures are types of orders for which the design makes a big difference.	Information displays array order information in the way that physicians are accustomed to thinking about orders, including consideration of the type and amount of information physicians are required to enter.	The design approach influences how much effort is required to learn and use the system to write actionable orders.
2. Ease of locating the orders of interest for each patient.	Options are available for the physician to locate and call up individual and groups of orders for a particular patient, including personal and departmental favorites, diagnosis- or situation-specific care sets, and order sets incorporating options and instructions relating to options.	The effort physicians must expend locating orders in the system contributes to the time required for writing orders.
3. Ability to accommodate all order types.	All types of orders – including laboratory, radiology, and pharmacy can be generated using the same orders module and screens.	Using different modules and screens to complete all orders for a specific patient is time consuming.
4. Design of messages and tasks so that a physician can easily identify and attend to outstanding items by type, by patient, by urgency. Good designs include an "inbox" and annotated patient lists.	New information (new lab results and alerts requiring attention) and outstanding tasks (orders expiring, orders to sign) are clearly identified; flagged as new, abnormal and/or STAT; and easily viewed.	For physicians, an important part of the value proposition for doing electronic ordering is assistance with handling patient management and communication tasks.
5. Delivery of prompts and alerts to guide and critique ordering at the most useful time for the physician.	Clinical decision support information is delivered when the physician is considering what to order, aiding in the selection of appropriate orders or recommending appropriate dosing or other parameters.	The sooner decision support feedback is integrated into ordering tasks the better. The worst case is an array of alert messages delivered at the time the physician is attempting to sign orders.
6. Ease of responding to prompts and alerts for orders.	Physician can display in one view and accept with one click all advice about order interventions, recommended doses, and other order elements.	This feature has a big effect on time to accomplish ordering, as well as acceptance of clinical decision support that CPOE can deliver. The worst case is requiring the physician to start over writing the order rather than quickly accepting a recommended change.

B. Critical CPOE Requirements for Implementation

Requirement	Description	Implication
1. Physician portal technology that facilitates universal physician access to CPOE.	System offers a physician portal and connectivity for remote access that is reliable and easily implemented and maintained (many CIOs look to browser-based technology for these characteristics).	Physicians must be able to access CPOE whenever they are making decisions about their patients – in the hospital, at their office or from home.
2. Integration with the pharmacy application, enabling the necessary two-way flow of data between the CPOE and pharmacy applications and ensuring that patient care and pharmacy processes are based on the same information.	Medication orders are seamlessly transmitted from the CPOE system to the pharmacy application, and an electronic acknowledgement of medications dispensed is automatically sent from the pharmacy application back to the CPOE system. The best way to validate this requirement is by contacting current implementation sites for the vendor.	Physicians order medications a certain way, whereas pharmacists often need to process orders and prepare medications for distribution employing different units of measure. Making the necessary translations can be difficult.
3. For hospitals with a current or planned electronic medication administration record (MAR), interoperability enabling the necessary two-way flow of data between the CPOE and MAR applications and ensuring that ordering and medication processes are based on the same information.	Medication orders are seamlessly transmitted from the CPOE system to the MAR application, and an electronic acknowledgement of medications administered is sent from the MAR application back to the CPOE system. The best way to validate this requirement is by contacting current implementation sites for the vendor.	Without this interoperability, physicians can't be provided with a real-time view of administration status for their orders with pertinent nursing comments (patient response, vital signs taken at administration, etc.) and nurses must enter STAT (first-dose) orders for physician orders not yet verified by pharmacy.
4. Design for a mobile device that physicians can use for CPOE and that mimics as much as possible the screen layout they see on the fixed workstation.	Mobile devices offer a fully-functional range of electronic tasks that physicians perform.	Mobile computing is a requirement for physician acceptance. The ability to write orders, as well as look at results, on the mobile device becomes essential once physicians are engaged in CPOE.
5. Comprehensive display of current orders for physician sign-off.	Order displays allow physicians to view all current patient orders, along with new orders, when the physician is electronically signing orders.	This is a pending requirement of the JCAHO.
6. Reports detailing for each physician the volume of inpatient orders entered directly into CPOE versus written or communicated verbally.	Physician leaders and project staff need to monitor physician utilization to assess progress and target individual physicians for additional training and follow-up. For this purpose, the CPOE application needs to make reports available on a scheduled and ad hoc basis.	Both for managing roll-out and for substantiating utilization statistics requested by external parties, project leaders need access to system reports.

C. Critical CPOE Requirements for Performance

Requirement	Description	Implication
1. Drug-drug and drug-allergy interaction checking; drug-drug duplicate and therapeutic overlap checking.	CPOE system links to the patient's current medication profile and automatically screens new orders for preventable drug interactions and duplications.	These tools are necessary to perform basic checking of medication orders for appropriateness.
2. Hospital control of the level of checking for standard medication screening.	System can set different levels of severity alerting for individual medications.	This feature is important for sufficiently fine-tuning medication-related advisories and alerts so as to achieve an acceptably low level of "nuisance" alerts.
3. Single and cumulative medication dosage checking.	System automatically factors into dosage checking the accumulated doses for a medication during a patient's stay.	This feature is necessary to extend dosage checking to some high-risk medications.
4. Medication-laboratory checking.	System automatically screens patient history for relevant laboratory results to detect possible contraindications with certain medications.	This feature is necessary for screening certain high-risk medications.
5. Medication dosage checking incorporating patient-specific age, weight, diagnosis, and other information.	System automatically factors relevant patient information into dosage checking, as relevant to particular medications requiring this level of detail.	This feature is necessary for screening many high-risk medications.
6. Patient-specific medication dosage checking set-up that does not require writing a unique rule for each unique set of conditions to be flagged.	Table-driven design, which simplifies establishing and maintaining the rules for drug checking. A good way to evaluate this feature is to ask for a demonstration of the process for setting up patient-specific dosing.	Writing individual rules (using a rules engine) is not practicable for the large number of situations involved.
7. Automatic display of linked secondary orders.	System displays additional recommended orders to accompany an order (e.g., laboratory test to titrate dosing based on medication blood level achieved).	This is a proven tool for addressing omissions in care management.
8. Laboratory duplicate checking.	System flags laboratory tests as potentially unnecessary duplicates based on hospital-established time limits for prior tests.	This is a proven tool for reducing unnecessary testing.
9. Automatic display of laboratory test results and vital signs relevant to medication order.	System can associate medications and relevant lab tests for automatic display with a medication order.	This both reminds a physician to consider the relevant information and makes it easy to do so.
10. Pre-defined sets of orders for a particular diagnosis and/or situation (e.g., post-op).	Physician can select and edit sets of orders as necessary before signing. Ideally physicians have several options such as order sets, diagnosis finder, order sets including likely options, intelligent care sets –customizable at the individual physician level.	Pre-defined orders are developed to incorporate recommended clinical practices.
11. Cost advisories.	System displays orderable item costs as part of an order template and/or recommendations concerning lower-cost interventions for patient.	These are proven tools for encouraging cost-effective care management and reminding physicians of applicable recommendations of hospital committees.
12. Medication orders default to formulary options or list those first.	Making the selection of formulary medications easy increases compliance with formulary management.	Formulary management can improve the cost-effectiveness of medications ordered. Incorporating formulary advisories in CPOE increases compliance with hospital formulary.