

Meaningful Use of Computerized Prescriber Order Entry

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Objective: It is the objective of this article to provide a guide to health care providers adopting computerized prescriber order entry (CPOE) and to explain recent developments of important concepts and initiatives such as “meaningful use” that will have significant impact on successful implementation of CPOE. The specific goals are to discuss key concepts relating to the NEW ARRA/HITECH–EHR meaningful use criteria and its relevance to CPOE Safe Practice and medication safety, summarize and update the recent scientific evidence evaluating CPOE, present the new 2010 CPOE safe practice, and suggest ways the CPOE safe practice may be expanded and harmonized with the new EHR meaningful use criteria.

Methods: This article evaluates the latest published studies in the field of CPOE and reexamines the objectives, the requirements for achieving these objectives, and evidence of efficacy for this practice. It reviews relevant issues of medication safety, the likely impact of CPOE, the efficacy of CPOE in various studies, key measures of impact of the practice, and important implementation issues. The 2010 updates to the National Quality Forum CPOE practice are also reviewed with support from the evidentiary base.

Results: This paper has presented an update to the National Quality Forum Safe Practice on CPOE for 2010. Although the practice itself has not changed, the scientific evidence of the impact of CPOE on medication safety and quality of care continues to accumulate. However, the adoption of CPOE by hospitals in the United States remains very low, as low as 6% in 1 study.

Conclusions: The adoption of CPOE has been low despite increasing evidence that hospital patients are still experiencing significant rates of preventable adverse drug events. This low adoption rate will likely be impacted by the new ARRA/HITECH legislation and the meaningful use concept.

Key Words: CPOE, medication safety, health information technology, meaningful use, ARRA, HITECH

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The National Quality Forum originally designated computerized physician order entry (CPOE)—the electronic entry of physicians’ orders into a clinical computer system for patient care—as one of its 30 Safe Practices for Better Healthcare in 2003. Since that time, the practices have been expanded to 34; the CPOE practice was updated in 2006, 2009, and now in 2010; and the body of knowledge about and experience with CPOE has grown considerably. This paper evaluates the latest published studies on CPOE and reexamines the objectives, the

requirements for achieving these objectives, and evidence of efficacy for this practice. It reviews relevant issues of medication safety, the likely impact of CPOE, the efficacy of CPOE in various studies, key measures of impact of the practice, and important implementation issues. It also reviews the new ARRA/HITECH Legislation and the potential impact of the “meaningful use” concept on the CPOE safe practice standard. It is the intention of this paper to provide a guide to health care providers adopting CPOE and to explain recent developments of important concepts and initiatives, such as “meaningful use” that will have significant impact on successful implementation of CPOE.

The 2010 updates to the National Quality Forum CPOE practice are reviewed with support from the evidentiary base.

COMPUTERIZED PHYSICIAN ORDER ENTRY SAFE PRACTICE

Computerized physician order entry (CPOE) has attracted significant attention recently as the ability of this practice to impact the safety of care has been questioned, and the complexity and significant costs of implementation of this health care intervention have become clearer.¹ The principal justification for recommending CPOE as a patient safety best practice has come from studies that have measured the impact of CPOE on medication safety: specifically preventing medication errors and serious medication errors.^{2,3}

However, newer studies have shown not only a reduction in serious medication errors, but a number of them suggest that there is also a decrease in the frequency of adverse drug events (ADEs) as expected. Additionally, CPOE has many other effects and has, for example, been shown to impact quality of care through optimized compliance with guidelines, improve outcomes with certain conditions such as acute myocardial infarction (AMI) and congestive heart failure (CHF), and improve reconciliation of medications across the continuum of care. The current challenge is that CPOE continues to be a practice with a low level of adoption across hospitals in the United States. Complete adoption of CPOE may currently occur in as few as 6% of U.S. hospitals,⁴ with private hospitals much more likely to adopt than public, and urban more than rural hospitals, but other studies show that large nonprofit teaching hospitals are the only ones with high penetration of CPOE.⁵ Adoption of CPOE in community hospitals remains a major challenge, despite a new study of community hospitals in 2008, which found that more than 10% of inpatients in these hospitals still experience ADEs that are preventable by CPOE and other interventions.⁶ Clearly, in 2010, this safe practice still remains a poorly adopted technology in most U.S. hospitals. This is one reason why CPOE figures so prominently in the new American Recovery and Reinvestment Act of 2009/Health Information Technology for Economic and Clinical Health Act (ARRA/HITECH) Electronic Health Records (EHRs) meaningful use criteria which will probably strongly incent the adoption of CPOE.⁷

The goals of this report are to discuss key concepts relating to the NEW ARRA/HITECH–EHR meaningful use criteria and its relevance to CPOE Safe Practice and medication safety,

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summarize and update the recent scientific evidence evaluating CPOE, present the new 2010 CPOE safe practice, and to suggest ways the CPOE safe practice may be expanded and harmonized with the new EHR meaningful use criteria.

MEANINGFUL USE OF ELECTRONIC HEALTH RECORDS

In the landmark report *"To Err is Human,"* the Institute of Medicine (IOM) called for the adoption of EHRs as an essential infrastructure for improving the safety and quality of care in the United States.⁸ During the past decade, many hospitals and ambulatory care sites have begun implementing EHRs, but most care is still delivered without these systems. Furthermore, recent studies reveal that, despite considerable investment in these systems, many organizations have so far made only limited use of the most powerful capabilities of these systems to improve the quality and safety of care.⁹

The U.S. government has previously invested relatively little in Health Information Technology (HIT) compared with other nations, and lags far behind many other developed countries with respect to HIT adoption. However, this level of investment is about to change radically—the American Recovery and Reinvestment Act of 2009 (ARRA, also called HITECH) provides up to \$45 billion dollars for the adoption and use of HIT; previous federal spending on HIT in this area was approximately \$50 million per year.¹⁰ Most of this funding will go as financial incentives to physicians (individual providers) and hospitals able to demonstrate that they are using “certified EHR technology in a meaningful manner.”¹⁰ The ARRA underscores several specific areas of EHR use that fit the overall EHR-enabled improvements called for by the IOM. For both the hospital and the physician delivering ambulatory care, these requirements include “using the EHR to report on designated clinical quality measures, to exchange health information to support continuity of care, and to write orders electronically (CPOE) or electronic prescribing (e-Rx), respectively, to gain the benefit of clinical decision support (CDS) to improve the safety and quality of patient care.” The ARRA legislation is not fully prescriptive regarding the details for meaningful use in these functional areas, and much discretion was left to Health and Human Services in the form of rule making to determine what should be considered “meaningful use” of EHRs.

Tying financial incentives to the concept of meaningful use is essential, because merely implementing an EHR does not necessarily mean that providers are using the software in a manner necessary to achieve the desired improvements in care. The EHR vendor products are not all the same and cannot be used “out of the box”; local organizational EHR configuration and customization are always required regardless of the setting of care. In one survey, in the 14.8% of U.S. nongovernment hospitals using CPOE, only 70% were using any decision support in CPOE, only 52% had CPOE in use for all inpatient beds, and only 39% had physicians entering at least 75% of orders.¹¹ Similarly, in the outpatient setting, national data show that simply using an electronic health record was not associated with improved quality of care across a wide array of quality measures.¹²

The starting point, for any hospital or other health care setting attempting to achieve financial incentives from the ARRA/HITECH act, is to select an EHR product that includes the functions and features necessary to achieve meaningful use (the right product). The ARRA is explicit that “the EHR technology used must be certified.” That certification should be in compliance with the current Certification Commission for HIT

approach¹³ (a process that is already in place for certifying EHR vendors for both the hospital and ambulatory setting). Clearly other vehicles will be available for certification in the future. At a minimum, enhancements in these criteria can be expected in the scope of functions to be certified for the qualifying inpatient EHR to incorporate data capture and reporting for quality measurement. For all care settings, it is also likely that currently certified health information exchange capabilities will be expanded to include the Continuous Care Document (an existing HIT EHR standard which is a vehicle for transmitting patient clinical summaries from one provider to another, especially important in primary care settings, as well as capabilities for medication reconciliation across the continuum of care. The EHR certification may also be expanded to address ease of use by providers and additional safeguards to protect patient privacy and information security.¹³

For meaningful use, certification, although necessary, is, alone, insufficient. The idea of the concept is that a good electronic record must not only be selected, but must also be used in a meaningful way by providers so that the desired results included reduced costs; and, additionally, improved quality and safety are achieved. Thus, how certified EHRs are actually implemented and adopted by providers is even more important than which record is selected. First, the manner in which the EHR software is implemented (what features are turned on and applied) must offer providers the key for the capabilities needed to use it in a meaningful way (right implementation). Second, physicians, nurses, and other health care workers must incorporate the use of the EHR into their routine workflow. For hospitals, the ARRA states that this bar (standard) will be raised over time, and the same is both desirable and essential for the physician incentives; this EHR meaningful-use model will be implemented incrementally, with increasing requirements from 2011 to 2015. The process around this is that recommendations about meaningful use are made to the Office of the National Coordinator by the Health Information Policy Committee and Standards Committee, and the National Coordinator’s Office then works with the Centers for Medicare & Medicaid Services to produce the actual payment recommendations. The inpatient CPOE recommendations received the most comments of any of the recommendations released by the HIT Policy committee in July 2009, with most comments focusing on the timing of implementation, which was initially to target full implementation by 2011. This was adjusted to 10% implementation by 2011, with full implementation likely required by 2013 (See Table 1).

Because of the urgent call by the IOM and others for improved patient safety in the hospital setting, the targeted EHR functionality does include CPOE with CDS, capability for health information exchange, and electronic clinical documentation for both nurses and physicians. The right implementation must include setup and configuration of CPOE to cover all types of orders, and to leverage the CDS tools, at a minimum, to address the common, serious ADEs that still occur in hospitals today. The right implementation must also accommodate the electronic clinical information exchanges that will be occurring with increasing frequency at patient admission and discharge, as more physician practices and other providers are able to participate in electronic exchanges during patient transitions in care. This should include the ability to exchange structured problem lists, labs, and radiology test results. Medication management, including administration and dispensing, is included because these care processes, like order writing, can be made significantly safer through the use of such interventions as an electronic medication administration record (eMAR) with bar coding.¹⁴

TABLE 1. Proposed EHR Meaningful Use Criteria That Impact CPOE

Health Policy Goals	Intervention	Stage 1	Stage 2
		2011	2013
Improving safety and quality	CPOE	<ul style="list-style-type: none"> • 10% of all orders (any type) directly entered by authorizing provider (e.g., MD, DO, RN, PA, NP) through CPOE • Implement drug-drug, drug-allergy, and drug-formulary checks • Maintain an up-to-date problem list of current and active diagnoses based on ICD-9 or SNOMED (80% of unique patients) • Maintain active medication list (80% of unique patients) • Maintain active medication allergy list (80% of unique patients) • Implement 5 clinical decision rules related to high clinical priority, and track compliance 	<ul style="list-style-type: none"> • Use CPOE for all order types • Use evidence-based order sets • Conduct closed-loop medication management, including eMAR and computer-assisted administration • Record all clinical documentation in EHR • Generate and transmit permissible discharge prescriptions electronically. Use clinical decision support at the point of care (e.g., reminders and alerts)
Improve care coordination	Exchanging meaningful clinical information	<ul style="list-style-type: none"> • Perform medication reconciliation at relevant encounters and at each transition of care 	<ul style="list-style-type: none"> • Perform medication reconciliation at each transition of care from one health care setting to another

Assessing the right adoption of the hospital EHR will require standards concerning the extent to which clinicians actually perform the targeted tasks electronically. For CPOE, a logical measure is the percentage of inpatient orders physicians actually enter electronically. As one of the recommended National Quality Forum (NQF) safe practices, The Leapfrog Group has set a standard that at least 75% of medication orders be entered by physicians or licensed providers with CPOE.¹⁵ Although the current EHR meaningful use criteria do not specify a complete CPOE standard, the current NQF Safe Practice for CPOE is a reasonable starting point and ultimately will need to be harmonized with the EHR meaningful use criteria that apply to CPOE (Table 1).

EVIDENCE FOR EFFECTIVENESS OF CPOE IN IMPROVING SAFETY OF CARE

Although CPOE has been in use for many decades in some hospitals, it was not until the last decade that studies appeared on its ability to improve patient safety. Two studies in the 1990s established the ability of CPOE systems to significantly reduce the incidence of serious medication errors⁵ and medication errors overall in hospitalized patients.³ The primary end-points for these studies were these proximal outcomes, and although preventable ADE rates were evaluated as secondary outcomes, the studies were not powered to be able to identify clinically meaningful differences in these rates. Although there was a trend toward reduction in the preventable ADE rate, no statistically significant reduction was found. The medication error reductions identified were found, although the level of decision support in Bates’ 1998 study was quite modest, with only default dosage suggestions, and limited drug-allergy and drug-drug interaction checking included.²

Newer studies, using more complex decision support approaches, have shown an impact of CPOE on both medication errors and ADEs, and also have addressed specific areas with respect to more advanced areas of decision support. Several

studies evaluated the impact of providing recommendations for dosage adjustments, based on renal function.^{16,17} These studies showed substantial improvement in the appropriateness of renal medication dosing, decreased length of stay in the intervention group among patients with renal failure, and a 50% reduction in renally inappropriate medication orders. Another study evaluated the impact of dosing suggestions for elderly patients for psychotropic drugs and found that this decision support was associated with a much lower level of overly-high initial dosage rates and a lower rate of falls in the intervention group.¹⁸ Several studies of CPOE in pediatric institutions have shown results similar to the experience in other hospitals. A Canadian organization demonstrated a 40% reduction in medication errors,¹⁹ whereas another study examining the effect of CPOE in a pediatric intensive care unit (ICU) showed a more dramatic 99% reduction in prescribing errors.²⁰ Other pediatric studies have shown similar effects,^{21,22} and a recent study found a significant reduction of ADEs, medication errors, and rule violations in a pediatric ICU after CPOE was implemented.²³

Several recent meta-analyses have also recently been published looking at the impact of CPOE, and they have found not only a reduction in medication errors associated with CPOE, but also either an actual reduction in ADEs or a reduction in the risk of ADEs.²⁴⁻²⁶

In addition to reducing active errors in ordering, CPOE can reduce errors of omission. Several studies have shown improved adherence to guidelines for safe medication use and monitoring (e.g., measuring serum drug levels) through the use of recommended corollary orders²⁷ and increased use of recommended preventive care measures (such as immunizations).²⁸ A study of computerized ordering of anti-infective agents in an ICU demonstrated a dramatic reduction in the incidence of ADEs, as well as decreased lengths of stay and total costs of care.²⁹ CPOE has also been linked to other improvements in quality of care, such as reduction in use of central line catheters,³⁰ and reduced cost of care and increased consistency of care when CPOE was implemented in remotely monitored ICUs.³¹ CPOE has also been associated with higher quality of care and better outcomes

under certain conditions.^{32,33} Finally, CPOE has been linked to improved compliance with medication reconciliation.^{34,35}

SAFETY OF CPOE

Several studies have been published suggesting that CPOE may directly contribute to an increase in the occurrence of medication errors.^{36–38} The study by Koppel et al. in particular, received widespread media attention; it is important to note that this study did not measure error or adverse event rates but instead asked about users' perceptions that CPOE could cause errors.³⁹ These studies do clearly make the important observation that CPOE, like any technology, can introduce errors or harm as well as prevent them, and that it is essential to monitor these systems and make changes to them to reduce the likelihood of errors being created. Technologies can, in fact, be especially pernicious as, for example, a decision support that regularly suggests the wrong thing could introduce very large numbers of errors. However, reports to the MEDMARX Program at USP have found very few suggesting that CPOE might have led to serious injuries or death.⁴⁰

Nonetheless, one pediatric hospital reported an increase in mortality in transfer patients in the immediate aftermath of CPOE implementation at their facility.⁴¹ The report serves to emphasize the stakes involved in implementing CPOE properly, and the lessons from this narrative offer many valuable insights into some of the hazards of the approach taken. Examination of the narrative of this hospital's implementation reveals a number of likely reasons why they observed this increase in mortality. This report reviewed the mortality in an acutely ill subset of the hospital's overall patient population—those patients transferred in from other facilities in need of acute care. Approximately 56.7% of the patients were initially admitted to the ICU. A number of factors seem to have resulted in significant delays in therapy for these acutely ill children. This center implemented CPOE across the entire hospital in 6 days, rather than following a more traditional phased rollout approach (e.g., a pilot period followed by unit-by-unit rollout, evaluating and resolving problems throughout the course of the implementation). No process had been developed for registering patients in advance of admission, which prevented the medical staff from writing orders in preparation for the admission and thereby initiating medication and other therapy immediately upon patient arrival. Instead, ordering had to await the arrival of the patient. No intensive care-specific order sets had been developed in advance of go-live, resulting in the need to manually enter each individual order; for an ICU patient, this can mean the ad hoc entry of dozens of orders. In addition, the system implemented required, in the words of the authors, “an average of 10” mouse clicks per order, or 1 to 2 minutes for each order. Other aspects of network and system performance further exacerbated this problem. Finally, and perhaps most importantly, the hospital made the decision to remove all medications from the ICU to the central pharmacy, preventing the prompt administration of critical medications pending electronic ordering. These and other elements of the implementation strategy seem to have resulted in measurable delays in therapy; whereas, before CPOE, antibiotics and critical infusions pressors, etc.) had been administered to these patients within recommended timelines. More than half of these patients failed to receive the medications in a timely fashion after CPOE implementation.⁴¹ Newer studies continue to outline the safety risks related to the use of these complex systems, especially with increasingly common rapid implementations, although none with the poignancy of the case study described above.^{42,43}

In summary, these important reports serve to reinforce the importance of a carefully considered CPOE implementation plan and the need for a responsive application and supporting

network infrastructure for the safe and effective performance of CPOE. A decision to implement CPOE represents a decision to possibly interfere in a highly invasive manner in one of the most critical processes in patient care. Although a good CPOE implementation may yield significant benefits, if done sub-optimally, it carries the potential to harm patients. This becomes even more important as meaningful use increases the likelihood of rapid EHR and CPOE implementations, and the relentless pressure to bypass workflow assessment and process redesign increases. This may result in rapid implementations that cause harm to patients.⁴⁴ Several new studies have demonstrated the great importance of these interventions in successful CPOE implementations,^{45–47} and suggestions have been made about how to maintain patient safety during and after these CPOE implementations.⁴⁸

CPOE MEASURES

In evaluating safety improvements from CPOE, the most distal outcome measure is the preventable ADE. Most studies evaluating effectiveness of systems at improving safety have concentrated on medication errors, as these measures are more frequent and thus less expensive to identify; however, new studies are increasingly measuring ADEs as the outcome measure of interest.

Structural measures of CPOE effectiveness—successful implementation and adoption, for example—are probably associated with a substantial variation in level of impact. There are simply too many variables in the details of each implementation—nature and quality of decision support, communication with other information systems, physician adoption, and use patterns, to name a few—to be certain about the impact on effectiveness without examining effects on care processes or outcomes. Recent studies describing how poorly a CPOE system can perform with broad adoption illustrate that errors can still occur in this situation as well.^{36,49} One key message from these studies is that it is essential to make changes in the CPOE application, even long after it is implemented, to try to “engineer out” errors and problems created by the applications.³⁷

An example of the use of process measures to evaluate CPOE effectiveness is The Leapfrog Group's methodology for assessing CPOE systems implemented in hospitals.⁵⁰ This methodology estimates a system's potential effect on safety by examining how it handles dangerous ordering scenarios. The protocol measures a system's rate of interception of specific ordering errors. Each error is scored for significance, based on the estimated frequency and severity of the potential resulting ADE, as derived from literature and expert consensus. Thus, the methodology attempts to couple, as closely as possible, a specific process measure (error) to a specific outcome (ADE).

In addition to measuring a system's ability to stop or prevent dangerous errors (errors of commission), one can measure a CPOE system's ability to reduce errors of omission, thereby contributing to improved safety. For example, CPOE can increase adherence to practices for improving safety (such as the monitoring of a medication's side effects or blood levels).²⁸

Beyond measures of safety, investigators have successfully measured CPOE's ability to enhance other measures of clinical quality, such as effectiveness and efficiency. In the realm of effectiveness, CPOE can improve adherence to preventive health measures (e.g., reminders to immunize vulnerable patients),²⁸ and can enhance ordering of protective measures such as subcutaneous heparin and H2 blockers in appropriate patients.⁵¹ CPOE can also improve aspects of efficiency of care. One study demonstrated a reduction in total hospital charges and length of

stay.⁵² Another showed decreases in medication turnaround times, elimination of transcription errors, and improvements in order countersignatures.⁵³ Overall, it is important to note that CPOE has many beneficial effects, and that the medication safety benefit is only a small part of the overall benefit.

PRACTICES TO INCREASE LIKELIHOOD OF SUCCESSFUL CPOE IMPLEMENTATION

A number of practices have been shown to be beneficial to the successful and safe implementation and operation of CPOE.³⁸ At the time that this safety practice was first recommended, well-described success factors included executive leadership commitment to project and budget; involvement of physicians as key decision makers from the outset; use of a dedicated physician champion; multidisciplinary planning and implementation teams which include representatives of nursing and pharmacy; scrupulous attention to and anticipation of workflow changes with implementation; superb system performance with rapid, subsecond response times; use of multiple, flexible approaches to physician training and support; and other factors.⁵⁴ In addition, the importance of human factor considerations in the design and implementation of CPOE systems is essential.^{44,55}

An increasing number of community hospitals have implemented CPOE in recent years. Lessons for success in the community setting include all of the above. One important difference between community and academic medical centers are expectations of universal physician usage of CPOE; most community hospitals cannot mandate use as can academic medical centers with their house staff. This is due to the heterogeneity of practice patterns and volumes of community physicians and their voluntary status. Thus, most community hospitals that have succeeded with CPOE implementation have achieved partial, rather than full use, as can academic medical centers with their house staff. This is due to the heterogeneity of practice patterns and volumes of community physicians and their voluntary status. Thus, most community hospitals that have succeeded with CPOE implementation have achieved partial, rather than full, utilization by physicians; this continues to be a significant problem in achieving broad adoption of CPOE in community settings of care.⁵⁶ Most community hospitals in rural settings have financial limitations that impede the capital investment required to put these systems in place, and little implementation of CPOE has occurred in these rural hospitals.⁵⁷ Clearly, to achieve widespread implementation of CPOE in rural hospitals will require special financial and technical assistance, particularly of the type envisioned in the ARRA/HITECH legislation. However, it is not apparent from these studies that limited application of CPOE or discrete aspects of CPOE (presumably at lower cost) will provide significant safety benefits. Indeed, these studies suggest that CPOE, when implemented in rural hospitals, should conform to the same specifications included in any update to the 2010 NQF Safe Practice 16, "Safe Adoption of Computerized Prescriber Order Entry," without exception.^{56,58}

Although studies of CPOE have not been reported from specialty hospitals beyond pediatric hospitals, they have been reported from specialty settings such as the ICU.^{59,60} Specific recommendations in specialty hospitals are not possible, given the current lack of published evidence on the use of this practice in specialty hospitals. However, lessons learned from general medical implementations about the importance of CPOE can most likely be translated for use within the specialty hospital setting.

The development of standardized order sets has been identified as a particular accelerator for successful CPOE adoption. For example, robust protocol-driven chemotherapy order sets have been very helpful in cancer specialty hospitals. When an organization can agree on such standardization before implementation of CPOE,^{54,56} not only is ease and speed of adoption enhanced, but the likelihood of subsequent error and harm is reduced by the reduction in variation.^{39,61}

The importance of all of these factors has only been underscored by one high-profile CPOE implementation that failed because physicians found the system slow, overly complex, and time-consuming in use.⁶² In part, to reduce these barriers, some have looked to the use of handheld mobile devices to increase physician adoption of CPOE.⁶³ Unfortunately, the workflow issue associated with ordering on personal digital assistant devices with small screens, which requires many screen flips to execute an order, has limited the widespread use of these devices, as have the processing limitations which make it difficult or impossible to deliver sophisticated decision support. Clearly, CPOE with these handheld devices presents a number of new challenges that will require further study to determine whether this approach can be made efficacious.⁶³

REQUIREMENTS TO IMPROVE PATIENT SAFETY WITH CPOE

A prerequisite to system effectiveness in improving safety is use of the system by physicians—a nontrivial accomplishment as demonstrated by past failures.^{64,65} Thus, the above requirement to promote physician use of CPOE is the essential starting point.

The CPOE systems eliminate many of the hazards of illegibility of physician handwriting. If they communicate electronically with pharmacy systems, they may also eliminate or greatly reduce transcription errors. In addition, systems properly implemented will display appropriate default dose and interval regimens for medications and prevent entry of incomplete orders. Many organizations that implement CPOE have found a consequent rise in verbal orders that can limit the impact of CPOE. Care must be taken to ensure that CPOE does not lead to a dramatic rise in the use of verbal orders, which clearly provide the same or higher risk for transcription errors as do written orders.

To reduce the likelihood of errors leading to ADEs, CPOE systems must provide some level of decision support to the prescriber. Drug-drug and drug-allergy interaction checking represents a basic level of decision support. Most systems contain drug databases and allergy logic to accomplish these functions. "However, commercial databases for detecting drug-drug interactions may not discriminate effectively between significant and trivial interactions, thus decreasing the value of this information; in addition, allergy alerts are frequently overridden in practice because of the poor quality of allergy data in many systems." (Peter Kilbridge, MD, oral communication, October 14, 2005)

Other categories of decision support that may reduce the likelihood of harmful errors include suggestions about renal dosing,⁶⁶ suggestions about age-based dosing⁶⁷ reminders to monitor drug levels,²⁸ alerts based on drug-lab⁶⁶ and drug-disease interactions, duplicate order checking, weight-based dosing recommendations, and dose limit checking.⁵⁰

Decision support that combines multiple sources of current, patient-specific physiological data with medication information provides the greatest opportunity for effective intervention to reduce patient harm. For example, studies that have shown an

unequivocal reduction in ADEs with computerized ordering (albeit in a single specialized environment) used a computer system that combined patient demographic, medication, allergy, and laboratory data (including microbiology data on sensitivities of infective organisms) to formulate recommendations for antibiotic therapy.^{67,68}

Clearly, as the example above illustrates, effective integration of clinical information plays an important role in the impact of CDS on medication safety. Certain types of integrated information are critical for an effective and safe medication use process, driven by CPOE. For example, an integrated CPOE and Pharmacy Module allows physicians and pharmacists to easily

TABLE 2. 2010 NQF CPOE Safe Practice

Practice and Care Settings	Additional Specifications
<p>Safe Practice 16: Safe Adoption of Computerized Prescriber Order Entry</p> <p>Implement a computerized prescriber order entry (CPOE) system built upon the requisite foundation of re-engineered evidence-based care, an assurance of healthcare organization staff and independent practitioner readiness, and an integrated information technology infrastructure.</p>	<ul style="list-style-type: none"> • Providers enter orders using an integrated, electronic information management system that is based on a documented implementation plan that includes or provides for the following: • Risks and hazards assessment to identify the performance gaps to be closed, including the lack of standardization of care; high-risk points in medication management systems such as at the point of order entry and upon the administration of medications; and the introduction of disruptive innovations. • Prospective re-engineering of care processes and workflow. • Readiness of integrated clinical information systems that include, at a minimum, the following information and management systems: <ul style="list-style-type: none"> • Admit discharge and transfer (ADT). • Laboratory with electronic microbiology output. • Pharmacy. • Orders. • Electronic medication administration record (including patient, staff, and medication ID) (eMAR). • Clinical data repository with clinical decision support capability. • Scheduling. • Radiology. • Clinical documentation.
<p>Applicable Clinical Care Settings</p> <p>This practice is applicable to CMS care settings, to include inpatient service/hospital.</p>	<ul style="list-style-type: none"> • Readiness of hospital governance, staff, and independent practitioners, including board governance, senior administrative management, frontline caregivers, and independent practitioners. • The following CPOE specifications, which: <ul style="list-style-type: none"> • Facilitate the medication reconciliation process; • Are part of an Electronic Health Record Information System or an existing clinical information system that is bi-directionally and tightly interfaced with, at a minimum, the pharmacy, the clinical documentation department (including medication administration record), and laboratory systems, to facilitate review of all orders by all providers; • Are linked to prescribing error-prevention software with effective clinical decision support capability; • Require prescribers to document the reasons for any override of an error prevention notice; • Enable and facilitate the timely display and review of all new orders by a pharmacist before the administration of the first dose of medication, except in cases when a delay would cause harm to a patient; • Facilitate the review and/or display of all pertinent clinical information about the patient, including allergies, height and weight, medications, imaging, laboratory results, and a problem list, all in one place; • Categorize medications into therapeutic classes or categories (e.g., penicillin and its derivatives) to facilitate the checking of medications within classes and retain this information over time; and • Have the capability to check the medication ordered as part of effective clinical decision support for dose range, dosing, frequency, route of administration, allergies, drug-drug interactions, dose adjustment based on laboratory results, excessive cumulative dosing, and therapeutic duplication.

TABLE 3. Authors' Recommendations for NQF Consensus Standard Revisions**Future Specifications to Consider as Updates for the Safe Practice on CPOE**

1. At least 75% of CPOE orders should be entered by the licensed prescriber.
2. The CPOE system is tested against the CPOE Simulator System.
3. The CPOE system maintains an up-to-date problem list of current and active diagnoses based on ICD-9 or SNOMED.
4. The CPOE system maintains an active medication list.
5. The CPOE system maintains an active medication allergy list.
6. The CPOE system performs medication reconciliation at relevant encounters and each transition of care.
7. The CPOE system uses evidence-based order sets.
8. The CPOE system conducts closed-loop medication management, including eMAR and computer-assisted administration.
9. The CPOE system is part of a certified, complete EHR Product.

and effectively share CDS information, including alerts, overrides, and order changes. Additionally, an integrated CPOE and Nursing Medication Administration record module allows similar communication and coordination between nurses and physicians as medications move from the order stage through administration. Tests conducted with the Leapfrog CPOE evaluation tool previously described revealed that the safest CPOE systems were those with tightly integrated CPOE, Pharmacy, and Nursing Medication Administration modules, often when all these modules were products from the same vendor.³⁹ These studies would support the notion that the use of discrete CPOE elements in a more limited fashion (which rural hospitals might be able to more easily afford) would not be associated with a clear safety benefit. Ultimately, CPOE applications will be most effective and safe when they are truly integrated systems that seamlessly offer results allowing complete data review, including images; ordering of all interventions with CDS that both reminds and questions medical decisions; and sophisticated interactive patient-sensitive disease management programs linked to real-time population and practitioner performance monitoring programs.

One of the important and ongoing challenges with effective decision support is alert fatigue because of over-alerting of physicians with many early and current CPOE systems; however, more and more studies are appearing to address this important issue, and they are identifying better approaches to alerting that will increase physician acceptance and lower physician alert fatigue.^{69,70}

Table 2 lists the 2010 NQF-endorsed Safe Practice 16 on CPOE specifications. The CPOE Standard in Table 2 is similar to the standard published in 2009 and includes no suggested revisions by the authors.⁵⁸ However, based on the soon-to-be released final EHR meaningful use criteria, the authors have suggested future revisions to the practice as shown in Table 3. These new suggestions in Table 3 are based on the new EHR meaningful use criteria, and the authors suggest several new standards for future consideration that would help harmonize the NQF safe practice with the new EHR meaningful use criteria. Still, additional research on CPOE is necessary and should target the impact of CPOE in other areas (e.g., psychiatric inpatients, oncology clinics, ambulatory clinics, and long-term care settings, among others), what decision support can provide further value, and how it can best be delivered. Another key

issue is that almost all the evaluations of CPOE to date have focused on internally developed systems. Scientific evaluations of vendor applications and evaluations from community hospitals would be especially valuable. Finally, further studies on the safety of CPOE systems, both during and after implementation, are critical, especially with the likely rush to implement these systems to attain financial incentives under the ARRA/HITACH act.

SUMMARY

This paper has presented the 2010 update to the 2009 NQF Safe Practice 16 on CPOE. Although the practice itself has not changed, the scientific evidence of the impact of CPOE on medication safety and quality of care continues to accumulate. However, the adoption of CPOE by hospitals in the United States remains very low, as low as 6% in one study, despite increasing evidence that hospital patients are still experiencing significant rates of preventable ADEs. This will likely be impacted by the new ARRA/HITECH legislation and the meaningful use of EHRs that it specifies.⁷¹ Future iterations of this NQF safe practice will need to incorporate and harmonize with this new EHR standard. It is being increasingly recognized that CPOE is the capstone of health information technologies adopted by providers, and that remote verification of performance is likely a wave of the future.

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