

The National Quality Forum Safe Practice Standard for Computerized Physician Order Entry: Updating a Critical Patient Safety Practice

Peter M. Kilbridge, MD,* David Classen, MD, MS,† David W. Bates, MD, MSc,‡ and Charles R. Denham, MD§

Abstract: The National Quality Forum has designated computerized physician order entry (CPOE)—the electronic entry of physicians' orders into a clinical computer system for patient care—as 1 of their 30 Safe Practices for Better Healthcare in 2003. Since that time, the body of knowledge and experience with CPOE has grown considerably. This article reexamines the objectives, requirements for achieving these objectives, and evidence of efficacy for this practice, and evaluates new published studies in CPOE. 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. Although it is clear that CPOE can cause errors as well as prevent them, the evidence clearly suggests that CPOE reduces the rates of medication errors and serious medication errors, although studies with adequate power to assess the impact of CPOE on the preventable adverse drug event rate have not been performed. Finally, updates and revisions to the current National Quality Forum CPOE practice standard and implementation examples are suggested.

Key Words: CPOE, medication safety

(*J Patient Saf* 2006;2:183–190)

Computerized Physician Order Entry (CPOE) has attracted significant attention recently as the ability of this practice to impact the safety of care has been challenged, and the complexity and significant costs of implementation of this health care intervention 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} Although a number of studies have measured the impact on the preventable adverse drug event (ADE) rate, the studies that

have been done have not been powered to detect differences in the preventable ADE rate, and the assumption has been that reducing serious medication errors (errors with the potential for harm or those that cause actual harm) will correlate with a decrease in the preventable ADE rate. Although this is very likely a valid assumption, it is also probably true that it is easier to decrease the number of near-misses than the number of preventable ADEs.

Another issue is that the true magnitude of the medication safety problem as measured by harm (i.e., ADEs) or by medication errors is still being elucidated, especially in the ambulatory setting, but also in inpatient settings.^{4–6} It has long been recognized that ADEs—harm to patients by drugs—constitute the single most common source of patient harm in the inpatient hospital setting.⁷ However, estimates of the frequency of ADEs vary, and there is no single agreed-upon criterion standard measure or estimate of the incidence of ADEs among hospital inpatients. Methods include classic chart review, self-reporting, observation, computerized surveillance, and targeted chart review.⁸ Studies of inpatient ADEs suggest that the more we look, the more we find,⁹ and the same is true in the outpatient setting, where contacting patients has resulted in identification of much higher ADE rates than chart review.⁴

The goals of this report are to: (1) summarize the evidence of the magnitude of the problem of medication safety; (2) to discuss key concepts relating to medication safety; (3) to review the measures that have been used to assess the impact of CPOE on medication safety, (4) to summarize the old and new evidence on the impact of CPOE on medication safety, (5) to discuss briefly keys to successful implementation, and (6) to present proposed revisions to the current standards based on the new evidence.

MAGNITUDE OF THE PROBLEM

More than 3 decades ago, Jick¹⁰ documented high ADE rates among inpatients using an observational method. Since that time, many different detection methods have been used to study and attempt to quantify ADEs, and different methods yield differing numbers. A large hospital-based study that used chart review, stimulated reporting, and incident reports in combination found an ADE incidence of 6.5%.¹¹ A recent chart review study in Canadian hospitals found an incidence of 7.5%.¹² In the 1990s, investigators using computerized automated surveillance methodologies (which looks for data

From the *Department of Pediatrics, St. Louis Children's Hospital and Washington University School of Medicine, St. Louis, Missouri; †The Division of Infectious Disease University of Utah School of Medicine, Salt Lake City, Utah; ‡The Division of General Internal Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts; and §The Texas Medical Institute of Technology, Austin, Texas.

Correspondence: Peter M. Kilbridge, MD, St. Louis Children's Hospital, 3S-36, Administration, One Children's Place, St. Louis, MO 63110 (e-mail: Kilbridge_P@kids.wustl.edu).

Copyright © 2006 by Lippincott Williams & Wilkins

combinations suggestive of an ADE) found incidence figures in the range of 2.4¹³ to 4.1⁹ ADEs per hundred admissions. When investigators in the latter study added chart review to their detection methods, the number of ADEs detected rose to approximately 10 per 100 admissions. Investigators using targeted chart review methodologies based upon the surveillance principle (e.g., the Institute for Healthcare Improvement's "ADE Trigger Tool") have demonstrated even higher ADE rates¹⁴; more recently, a prospective chart review study at a Veterans Affairs hospital reported an ADE incidence of 52 events per 100 admissions.¹⁵ Of note, this last study was conducted at a hospital with CPOE fully in place, raising concern about the types or severity of ADEs that might or might not be affected by this practice.

Some of the differences in incidence findings are attributable to differences in data types used by the detection strategies. For example, chart review permits screening of clinical documentation, such as comments in nursing notes, which are not currently accessible to most hospital computer systems and therefore will not be detected by automated surveillance.⁹ In addition, groups have used different definitions and approaches in studying ADEs. For example, different investigators have placed differing emphases on rigorous establishment of causality between drug administration and an adverse event.^{7,13,14,16} The preponderance of the evidence suggests that at least 5% to 10% of inpatients experience ADEs severe enough to require intervention in care. The future of ADE detection likely lies in computerized surveillance, which should improve in sensitivity as more electronic data become available.¹¹ Furthermore, the Institute of Medicine has called for development of consensus around definitions of medication errors and ADEs¹⁷; this would clearly facilitate comparisons among studies.

The definitions of and measures used to classify severity of ADEs have also varied widely among studies, making comparisons difficult. In the Harvard Medical Practice Study, which included only the most severe of ADEs, 14.1% of patients with ADEs experienced serious disability defined as disability persisting for over 6 months.⁷ A large study of ADEs based on stimulated reporting of events found that 1% of events were fatal, 12% life-threatening, 30% serious, and 57% significant.¹¹ A Canadian chart review study found that approximately 20% of ADE subjects experienced some degree of permanent injury.¹²

Although these and other sources of variation make comparisons between studies about medication safety challenging in evaluating interventions, the most important consideration is whether the same methodology was applied adequately in the intervention and control periods, and reliability about assessments was good. For most of the studies on CPOE, these criteria were met.

KEY CONCEPTS

There are several definitions and concepts whose understanding is requisite to the discussion of the goals and effectiveness of CPOE. A medical error denotes a failure in the process of care and can be defined as the failure of a planned action to be completed as intended (i.e., error of

execution) or the use of a wrong plan to achieve an aim (i.e., error of planning).¹⁸ A serious medication error is a medication error which either injures a patient (and is thus a preventable ADE) or carries the potential for harm, and is thus a near-miss.¹⁹ In contrast, an ADE describes an outcome and is defined as an injury to a patient by a drug.¹¹ As CPOE intervenes at 1 point in the medication management process (which includes ordering, pharmacy management, administration, and monitoring),²⁰ and as the number of medication errors greatly exceeds the number of ADEs,¹¹ the relationship between error prevention and adverse event prevention is loose, although it is stronger for serious medication errors than for medication errors overall (most of which have very low potential for harm). Not surprisingly, therefore, evidence for the effectiveness of CPOE (discussed later) is heavily weighted toward improvement in process (reduction of medication errors, appropriate ordering of preventive health measures, etc.).²¹ The evidence for effectiveness in preventing adverse events is currently much more limited. However, it is important to note that no studies have been supported by the federal government, which is essentially the only funder that supports studies large enough to adequately evaluate the impact of CPOE on preventable ADEs, which represent a fraction of all adverse events.

MEASURES

In evaluating safety improvements from CPOE, the most distal outcome measure is the preventable ADE. However, as described previously, no studies have been done with adequate power to assess the impact of CPOE on preventable ADEs because of their infrequency. Thus, the principle process measure is the serious medication error or medication error, and most studies evaluating effectiveness of systems at improving safety have concentrated on these measures.

Structural measures of CPOE effectiveness—successful implementation and adoption, for example—are probably associated with a substantial variation in the 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.^{22,23} One key message from these studies is that it is essential to make changes in the application even well after it is implemented to try to "engineer out" errors and problems created by the applications.²⁴

An example of the use of process measures to evaluate CPOE effectiveness is the Leapfrog Group's (LFG) methodology for assessing CPOE systems implemented in hospitals.²⁵ 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). Although this has good face validity, the correlation between a score on this test and the underlying error rate has not been measured.

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 monitoring of a medication's side effects or blood levels).²⁶

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)²⁷ and enhance ordering of protective measures such as subcutaneous heparin and H2 blockers in appropriate patients.²⁸ CPOE can also improve aspects of efficiency of care. One study demonstrated a reduction in total hospital charges and length of stay.²⁹ Another showed decreases in medication turnaround times, elimination of transcription errors, and improvements in order countersignatures.³⁰ 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 economic benefit.

EVIDENCE FOR EFFECTIVENESS IN IMPROVING SAFETY

A 2001 Agency for Healthcare Research and Quality-sponsored study of the effectiveness of patient safety practices ranked CPOE among those practices for which there is currently some evidence of effectiveness but for which additional research could be highly beneficial; a particular issue was that multicenter trials have not been done (although this would be nearly impossible with an intervention as complex and expensive as CPOE).³¹ Two studies in the 1990s established the ability of CPOE systems to significantly reduce the incidence of serious medication errors² and medication errors overall in hospitalized patients.³ The primary end points for these studies were these proximal outcomes, and although they were evaluated as secondary outcomes, the studies were not intended to address the difference in preventable ADE 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 et al² 1998 study was quite low, with only default dosage suggestions, and limited drug-allergy and drug-drug interaction checking included.

Subsequent studies have addressed specific areas with respect to more advanced decision support. One study evaluated the impact of providing recommendations for dosage adjustments based on renal function.³² This substantially improved the appropriateness of dosing and decreased

the length of stay in the intervention group, but did not affect the renal ADE rate. 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.³³

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 orders,²⁶ and increased use of recommended preventive care measures (such as immunizations).²⁷ A study of computerized ordering of anti-infective agents in an intensive care unit (ICU) demonstrated a dramatic reduction in the incidence of ADEs, as well as decreased lengths of stay and total costs.³⁴

Recently, several studies have been published suggesting that CPOE may directly contribute to an increase in the occurrence of medication errors.^{22,23,35} The study by Koppel et al²² 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.¹⁹ These studies do clearly make the important points that CPOE, like any other technology, can introduce errors as well as prevent them, and that it is essential to monitor CPOE systems and make changes to them to reduce the likelihood of errors being created by them. Technologies can be especially pernicious; for example, a decision support prompt that regularly suggests the wrong action could introduce large numbers of errors. However, reports to the MEDMARX Program at United States Pharmacopeia have shown very little evidence that CPOE can lead to serious injuries or death.³⁶ The studies also show that system performance is heavily dependent on quality of system design and implementation. Finally, they have increased the demand for further studies on the effectiveness of CPOE in enhancing safety.

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,³⁷ whereas another study examining the effect of CPOE in a pediatric ICU showed a more dramatic 99% reduction in prescribing errors.³⁸ Other pediatric studies have shown similar effects.^{39,40} None of these studies was powered to detect a difference in the preventable ADE rate.

To summarize, a number of studies have now demonstrated benefit in reducing medication error rates and serious medication error rates, although no studies have demonstrated that the overall medication error rate has increased. In addition, CPOE can clearly increase the rate of some types of errors.

One pediatric hospital recently 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 some valuable insights into some of the hazards of the approach taken. Examination of the narrative of their implementation reveals a number of likely reasons why they observed this

increase; it suggests that their findings arose from implementation choices that were unrelated to CPOE's ability to detect medication errors.

The report reviewed the mortality in an acutely ill subset of their overall patient population—those patients transferred in from other facilities in need of immediate care. 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, preventing 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 ad hoc entry of dozens of orders. In addition, the system implemented required, in the words of the authors, “an average of ten” 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 important, 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.) were administered to these patients within recommended timelines. More than half of these patients failed to receive these medications in a timely fashion after CPOE implementation.⁴¹ It should be noted that others from this institution previously reported measuring a decrease in ADEs after this CPOE implementation.⁴² However, for detection of ADEs, the authors relied on voluntary reporting, which has been shown to be anecdotal and of no use for quantitative purposes.^{43–45}

In summary, this important report by Han et al⁴¹ serves to reinforce the importance of a carefully considered implementation plan, and of a fast and responsive application and supporting network infrastructure for the safe and effective performance of CPOE. A decision to implement CPOE represents a decision to interfere in a highly invasive manner in one of the most critical processes in patient care. Although a good implementation may yield significant benefits, it carries the potential to harm patients if done suboptimally.

PRACTICES TO INCREASE LIKELIHOOD OF SUCCESSFUL IMPLEMENTATION

A number of practices have been shown to be beneficial—some essential—to the successful and safe implementation and operation of CPOE.³⁵ 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 including 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.⁴⁶ In addition, the importance of human factors considerations in the design and implementation of CPOE systems is essential.⁴⁷

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 regards expectations of universal physician use of CPOE; most community hospitals cannot mandate use as can academic medical centers with house staff; this is caused by the heterogeneity of practice patterns and volumes of community physicians and their voluntary status. Hence, most community hospitals that have succeeded with CPOE implementation have achieved partial, rather than full use by physicians.⁴⁸ However, 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.⁴⁹ Clearly, achieving widespread implementation of CPOE in rural hospitals will require special financial and technical assistance. 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 safety standards included in the update National Quality Forum (NQF) CPOE Practice 12 without specific exceptions of any part of the standard.⁴⁸

Although studies of CPOE have not been reported from specialty hospitals, they have been reported from specialty settings such as the ICU.^{50,51} 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 real accelerator of robust protocol-driven chemotherapy order sets and adoption of CPOE in cancer specialty hospitals. When an organization can agree on such standardization before implementation of CPOE,^{46,48} not only is ease and speed of adoption enhanced, but also the likelihood of subsequent error and harm is reduced by the reduction in variation.^{19,52–54}

The importance of all of these factors has only been underscored by a recent high-profile CPOE implementation that failed because physicians found the system slow, overly complex, and time consuming in use.⁵⁵ To reduce these barriers, some have looked to the use of handheld mobile

TABLE 1. Current NQF Standard for Practice 12 on CPOE⁶⁰

Practice and Care Settings	Additional Specifications
12. Implement a computerized prescriber order entry system. Applicable clinical care settings: acute care hospitals, although incremental implementation may be necessary in rural areas (as defined by the U.S. Census Bureau) and/or small community hospitals	<p>Prescribers should enter hospital medication orders using an automated information management system that:</p> <ul style="list-style-type: none"> • 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 (e.g., penicillin and its derivatives) to facilitate the checking of medications within classes and retains the 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; • Performs dose range checks to prevent excessive doses from being inadvertently ordered; and • Distinguishes between different doses of the same medication used for multiple indications, including off-label uses

Reprinted with permission from National Quality Forum. *Safe Practices for Better Healthcare: A Consensus Report*. Washington, DC: National Quality Forum; 2003.

devices to increase physician adoption of CPOE.⁵⁶ Unfortunately, the workflow issue associated with ordering on PDA devices with small screens that require 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 which will require further study to determine whether this approach can be made efficacious.⁵⁶

REQUIREMENTS TO IMPROVE SAFETY

A prerequisite to system effectiveness in improving safety is use of the system by physicians—a nontrivial accomplishment as demonstrated by past failures.^{57,58} Thus, the above requirements to promote physician use of CPOE are the essential starting point.

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 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 effec-

tively 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.⁵⁹

Other categories of decision support that may reduce the likelihood of harmful errors include suggestions about renal dosing,³² suggestions about age-based dosing,³³ reminders to monitor drug levels,²⁶ alerts based on drug-laboratory³² and drug-disease interactions, duplicate order checking, weight-based dosing recommendations, and dose limit checking.²⁵

Decision support that combines multiple sources of current, patient-specific physiologic 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.^{33,60}

As the example above illustrates, effective integration of clinical information plays an important role on the impact of clinical decision support 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 allow physicians and pharmacists to easily and effectively share clinical decision support information including alerts, overrides, and order changes. In addition, an integrated CPOE and Medication Administration Record module allows similar communication and coordination between nurses and physician as medications move from the order stage through administration. Tests conducted with the LFG CPOE evaluation tool described previously revealed that the safest CPOE systems were those with a tightly integrated CPOE,

TABLE 2. Proposed NQF Standard Revisions for Practice 12 on CPOE

Current Additional Specification	Suggested Revision	References
Prescribers should enter hospital medication orders using an automated information management system that:		
<ul style="list-style-type: none"> • Is linked to prescribing error prevention software 	Is linked to prescribing error prevention software with effective clinical decision support capability	References ^{25,59}
<ul style="list-style-type: none"> • Enables the review of all new orders by a pharmacist before the administration of the first dose of the medication 	Enables and facilitates timely display and review of all new orders by a pharmacist before the administration of the first dose, except in cases where a delay would cause harm to the patient	Reference ⁶¹ to JCAHO MM standard (MM 4.10)
<ul style="list-style-type: none"> • Permits the notation of all pertinent clinical information about the patient, including allergies, in one place 	Facilitates review and/or display of all pertinent clinical information about the patient, including allergies, medications, imaging and laboratory results, all in one place	Reference ⁵⁹
<ul style="list-style-type: none"> • Categorizes medications into families (e.g., penicillin and its derivatives) to facilitate the checking of medications within classes and retains this information over time 		
<ul style="list-style-type: none"> • Internally and automatically checks the performance of the information system 		Suggest elimination of this additional specification. Most hospital information technology systems are sophisticated enough to run real-time clinical applications and have programs that do this externally. Therefore, this is not a CPOE-specific criterion
<ul style="list-style-type: none"> • Requires prescribers to document the reasons for any override of an error prevention notice 		
<ul style="list-style-type: none"> • Performs dose range checks to prevent excessive doses from being inadvertently ordered and administered 	Has the capability to check the medication ordered for the following issues: <ul style="list-style-type: none"> • Dose range • Drug dosing • Drug frequency • Drug-drug interactions • Dose adjustment based on laboratory results • Excessive cumulative dosing • Drug allergies • Proper route • Therapeutic duplication 	Combine this additional specification with one below ^{25,59}
<ul style="list-style-type: none"> • Distinguishes between different doses of the same medication used for multiple indications, including off-label uses 		

JCAHO indicates Joint Commission on Accreditation of Healthcare Organizations; MM, Medication Management.

pharmacy and nursing medication administration modules, often when all these modules were of the same vendor product.¹⁹ These studies would support the notion that the use

of discrete CPOE elements in a more limited fashion (that rural hospitals might be able to more easily afford) would not be associated with a clear safety benefit. Ultimately, CPOE

TABLE 3. Proposed New NQF Standard Specifications for Practice 12 on CPOE

Suggested Specification	Comments
Prescribers should enter hospital medication orders using an automated information management system under the following conditions:	
At least 75% of all medication orders should be entered directly by the prescriber	Add as new implementation example ²⁵
System facilitates medication reconciliation process	Add as new additional specification JCAHO NPSG 8A and 8B
When available, the system is tested against LFG standards; including individual prescriber performance in relationship to LFG and other quality	Add as Implementation Example ²⁵
System is integrated or bidirectionally interfaced with pharmacy, nursing, and laboratory systems to facilitate review of all orders by all providers	Add as additional specification (the safest system is one with CPOE and pharmacy software tightly interfaced) ^{25,59}

JCAHO indicates Joint Commission on Accreditation of Healthcare Organizations; NPSG, National Patient Safety Goals.

applications will be most effective and safe when they are integrated systems offering ordering of all interventions with clinical decision support that both reminds and questions medical decisions, results that allow complete data review including images, and sophisticated interactive patient sensitive disease management programs linked to real-time population and practitioner performance monitoring programs.

Table 1 lists the current NQF Standard no. 12 on CPOE specifications. The suggested revisions to the practice are shown in Table 2. Most of the suggested revisions are relatively minor in nature. However, we have modified the standard on dose range checking to cover the standard on drug categories and the standard on different doses of the same drug for different indications. The revised dose checking standard now covers many aspects of medication use-checking, consistent with the important aspects of clinical decision support and the approach used in the new CPOE testing approach.²⁵ Table 3 includes the suggested addition to the current standard. We have added 2 new standards to bring the NQF standard into alignment with the existing LFG standard on CPOE, addressing the total number of medication orders that should be entered using the CPOE system and the LFG CPOE requirement that these CPOE systems be tested with the CPOE evaluation tool when available.²⁵ Based on the experience of many studies on the effective use of clinical decision support in CPOE, we have added a standard on the importance of integration or tight interfacing of the pharmacy system and the medication administration record system with the CPOE system.^{25,60} Finally, we have added a requirement, based on the new Joint Commission on Accreditation of Healthcare Organizations National Patient Safety Goals around medication reconciliation, that CPOE should be tightly integrated with any medication reconciliation program.⁶¹

Overall, the level of evidence associated with the efficacy of CPOE is stronger than it was 2 years ago, with the key differences being additional evidence about specific types of decision support and new evidence of efficacy in pediatrics. The evidence that CPOE prevents serious medication errors is increasingly strong, but no study has demonstrated the extent to which CPOE reduces the preventable ADE rate. However, it seems unlikely that such a study will be performed at this point. Additional research should target the impact of CPOE in other areas (e.g., psychiatric inpatients, the outpatient setting, and nursing homes, 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 to date of CPOE have focused on internally developed systems. Evaluations of vendor applications and evaluations from community hospitals would be especially valuable. These studies would be facilitated—especially in comparability—by better consensus about the definitions in the area of medication safety.

REFERENCES

- Berger RC, Kichak JP. Computerized physician order entry: helpful or harmful? *J Am Med Inform Assoc.* 2004;11:100–103.
- Bates DW, Leape LL, Cullen DJ, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA.* 1998;280:1311–1316.
- Bates DW, Teich JM, Lee J, et al. The impact of computerized physician order entry on medication error prevention. *J Am Med Inform Assoc.* 1999;6:313–321.
- Gandhi TK, Weingart SN, Borus J, et al. Adverse drug events in ambulatory care. *N Engl J Med.* 2003;348:1556–1564.
- Gurwitz JH, Field TS, Harrold LR, et al. Incidence and preventability of adverse drug events among older persons in the ambulatory setting. *JAMA.* 2003;289:1107–1116.
- Lazarou J, Pomeranz BH, Corey PN. Incidence of adverse drug reactions in hospitalized patients: a meta-analysis of prospective studies. *JAMA.* 1998;279:1200–1205.
- Leape LL, Brennan TA, Laird N, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *N Engl J Med.* 1991;324:377–384.
- Morimoto T, Gandhi TK, Seger AC, et al. Adverse drug events and medication errors: detection and classification methods. *Qual Saf Health Care.* 2004;13:306–314.
- Jha AK, Kuperman GJ, Teich JM, et al. Identifying adverse drug events: development of a computer-based monitor and comparison with chart review and stimulated voluntary report. *J Am Med Inform Assoc.* 1998;5:305–314.
- Jick H. Drugs-remarkably nontoxic. *N Engl J Med.* 1974;291:824–828.
- Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events. Implications for prevention. ADE Prevention Study Group. *JAMA.* 1995;274:29–34.
- Baker GR, Norton PG, Flintoft V, et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. *CMAJ.* 2004;170:1678–1686.
- Classen DC, Pestotnik SL, Evans RS, et al. Computerized surveillance of adverse drug events in hospital patients. *JAMA.* 1991;266:2847–2851.
- Resar RK, Rozich JD, Classen D. Methodology and rationale for the measurement of harm with trigger tools. *Qual Saf Health Care.* 2003;12(suppl 2):ii39–ii45.
- Nebeker JR, Hoffman JM, Weir CR, et al. High rates of adverse drug events in a highly computerized hospital. *Arch Intern Med.* 2005;165:1111–1116.
- Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med.* 1991;324:370–376.
- Institute of Medicine (IOM). Priority areas for national action: transforming health care quality. Adams K, Corrigan JM, ed. Committee on Identifying Priority Areas for Quality Improvement. Institute of Medicine of the National Academies. Washington, DC: The National Academies Press; 2003. Available at: www.nap.edu. Accessed October 23, 2006.
- Institute of Medicine (IOM). *Committee on Health Care in America. Crossing the Quality Chasm: A New Health System for the 21st Century.* Washington, DC: National Academies Press; 2001.
- Bates DW. Computerized physician order entry and medication errors: finding a balance. *J Biomed Inform.* 2005;38:259–261.
- Kilbridge P, Classen DC. Surveillance for Adverse Drug Events: History, Methods and Current Issues. [3]. 2002. Irving, TX, VHA Inc. VHA Research Series. VHA Inc. Ref Type: Serial (Book, Monograph).
- Brennan TA, Gawande A, Thomas E, et al. Accidental deaths, saved lives, and improved quality. *N Engl J Med.* 2005;353:1405–1409.
- Koppel R, Metlay JP, Cohen A, et al. Role of computerized physician order entry systems in facilitating medication errors. *JAMA.* 2005;293:1197–1203.
- Smith JA. Role of computerized physician order entry systems in facilitating medication errors. *J Urol.* 2005;174(4 pt 1):1400–1401.
- Bates DW. Computerized physician order entry and medication errors: finding a balance. *J Biomed Inform.* 2005;38:259–261.
- Kilbridge PM, Welebob EM, Classen DC. Development of the Leapfrog methodology for evaluating hospital implemented inpatient computerized physician order entry systems. *Qual Saf Health Care.* 2006;15:81–84.
- Overhage JM, Tierney WM, Zhou XH, et al. A randomized trial of “corollary orders” to prevent errors of omission. *J Am Med Inform Assoc.* 1997;4:364–375.

27. Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med*. 2001;345:965–970.
28. Teich JM, Merchia PR, Schmiz JL, et al. Effects of computerized physician order entry on prescribing practices. *Arch Intern Med*. 2000;160:2741–2747.
29. Tierney WM, Miller ME, Overhage JM, et al. Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. *JAMA*. 1993;269:379–383.
30. Mekhjian HS, Kumar RR, Kuehn L, et al. Immediate benefits realized following implementation of physician order entry at an academic medical center. *J Am Med Inform Assoc*. 2002;9:529–539.
31. Shojania KG, Duncan BW, McDonald KM, et al. Making health care safer: a critical analysis of patient safety practices. *Evid Rep Technol Assess (Summ)*. 2001(43):1–668.
32. Chertow GM, Lee J, Kuperman GJ, et al. Guided medication dosing for inpatients with renal insufficiency. *JAMA*. 2001;286:2839–2844.
33. Peterson HB, Thacker SB, Corso PS, et al. Hormone therapy: making decisions in the face of uncertainty. *Arch Intern Med*. 2004;164:2308–2312.
34. Evans RS, Pestotnik SL, Classen DC, et al. A computer-assisted management program for antibiotics and other antiinfective agents. *N Engl J Med*. 1998;338:232–238.
35. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system–related errors. *J Am Med Inform Assoc*. 2004;11:104–112.
36. Hicks RW, Santell JP, Cousins DD, et al. *MEDMARXSM 5th Anniversary Data Report: A Chartbook of 2003 Findings and Trends 1999–2003*. Rockville, MD: USP Center for the Advancement of Patient Safety; 2004.
37. King WJ, Paice N, Rangrej J, et al. The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients. *Pediatrics*. 2003;112(3 pt 1):506–509.
38. Potts AL, Barr FE, Gregory DF, et al. Computerized physician order entry and medication errors in a pediatric critical care unit. *Pediatrics*. 2004;113(1 pt 1):59–63.
39. Upperman JS, Staley P, Friend K, et al. The impact of hospital wide computerized physician order entry on medical errors in a pediatric hospital. *J Pediatr Surg*. 2005;40:57–59.
40. Cordero L, Kuehn L, Kumar RR, et al. Impact of computerized physician order entry on clinical practice in a newborn intensive care unit. *J Perinatol*. 2004;24:88–93.
41. Han YY, Carcillo JA, Venkataraman ST, et al. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. *Pediatrics*. 2005;116:1506–1512.
42. Cullen DJ, Bates DW, Small SD, et al. The incident reporting system does not detect adverse drug events: a problem for quality improvement. *Jt Comm J Qual Improv*. 1995;21:541–548.
43. Classen DC, Pestotnik SL, Evans RS, et al. Computerized surveillance of adverse drug events in hospital patients. *JAMA*. 1991;266:2847–2851.
44. Jha AK, Kuperman GJ, Teich JM, et al. Identifying adverse drug events: development of a computer-based monitor and comparison with chart review and stimulated voluntary report. *J Am Med Inform Assoc*. 1998;5:305–314.
45. Drazen E, Kilbridge P, Metzger J, et al. *A Primer on Physician Order Entry*. Oakland, CA: California HealthCare Foundation; 2000.
46. Saathoff A. Human factors considerations relevant to CPOE implementations. *J Healthc Inf Manag*. 2005;19:71–78.
47. Metzger J, Fortin J. *Computerized Physician Order Entry in Community Hospitals: Lessons from the Field*. Oakland, CA: California HealthCare Foundation; 2003.
48. Ohsfeldt RL, Ward MM, Schneider JE, 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. [Epub October 18, 2004].
49. Rothschild J. Computerized physician order entry in the critical care and general inpatient setting: a narrative review. *J Crit Care*. 2004;19:271–278.
50. Ali NA, Mekhjian HS, Kuehn PL, et al. Specificity of computerized physician order entry has a significant effect on the efficiency of workflow for critically ill patients. *Crit Care Med*. 2005;33:110–114.
51. Cohen MR, Anderson RW, Attilio RM, et al. Preventing medication errors in cancer chemotherapy. *Am J Health Syst Pharm*. 1996;53:737–746.
52. Joint Commission Resources Publication. *Preventing Medication Errors: Handwritten Orders Improving Healthcare Quality and Safety*. Available at: <http://www.jcrinc.com/printview.asp?durki=8670>. Accessed October 23, 2006.
53. Hicks RW, Nelson J, Santell JP. Medication errors associated with preprinted orders. USP Drug Safety Review. HSE 28 Drug Topics Health System Edition. March 22, 2004. Available at: <http://www.usp.org/pdf/EN/patientSafety/drugSafetyReview2004-03-22.pdf>. Accessed October 23, 2006.
54. Connolly C. *Cedars-Sinai Doctors Cling to Pen and Paper*. 2005. Available at: [washingtonpost.com](http://www.washingtonpost.com). Accessed October 23, 2006.
55. Ying A. Mobile physician order entry. *J Healthc Inf Manag*. 2003;17:58–63.
56. Massaro TA. Introducing physician order entry at a major academic medical center: II. Impact on medical education. *Acad Med*. 1993;68:25–30.
57. Hsieh TC, Kuperman GJ, Jaggi T, et al. Characteristics and consequences of drug allergy alert overrides in a computerized physician order entry system. *J Am Med Inform Assoc*. 2004;11:482–491.
58. Kaushal R, Shojania KG, Bates DW. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. *Arch Intern Med*. 2003;163:1409–1416.
59. The National Patient Safety Goals at the JCAHO. Available at: www.jcaho.org. Accessed October 15, 2005.
60. National Quality Forum. *Safe Practices for Better Healthcare: A Consensus Report*. Washington, DC: The National Quality Forum; 2003.
61. Medication Management (MM) Standards. Comprehensive Accreditation Manual for Hospitals (CAMH) 2005. Available at: www.jcaho.org. Accessed October 15, 2005.



TMIT

3011 North IH-35
Austin, TX 78722
(512) 473-2370

May 24, 2007

Dear Healthcare Leader:

We are delighted to announce that the Journal of Patient Safety has graciously given us permission to distribute copies of recently published articles to you in the interest of helping you adopt the *National Quality Forum Safe Practices for Better Healthcare – 2006 Update*.

The Journal of Patient Safety is dedicated to presenting research advances and field applications in every area of patient safety and we give our highest recommendation for them as a valuable resource toward patient safety from hospital bedside to boardroom. It is in the fulfillment of this mission that they make the gift of these articles to you in your pursuit of your quality journey.

The home page of the Journal of Patient Safety can be accessed at the following link:
<http://www.journalpatientsafety.com> and subscription information can be directly accessed online at:
<http://www.lww.com/product/?1549-8417>.

We want to acknowledge you and your institution for your current efforts in patient safety. We hope you enjoy this article and find it useful in your future work.

Sincerely,

Charles R. Denham, M.D.
Chairman
TMIT