Computerized Physician Order Entry Systems In Hospitals: Mandates And Incentives

Although no panacea, CPOE systems hold great potential to reduce medication errors.

by David F. Doolan and David W. Bates

ABSTRACT: Concerns with health care quality and medical errors are evident in media reports and research studies. A number of studies have demonstrated that computerized physician order entry (CPOE) can reduce medication error rates. In response, the California government and the Leapfrog Group have called for hospitals to implement CPOE for medications. However, few hospitals now use CPOE. Barriers include the large investment needed and the state of commercial CPOE systems. We argue that government, employers, and insurers should share the costs of CPOE and should fund further research into its benefits and means of implementation.

RECENT STUDIES DOCUMENT CONCERNS with the quality of U.S. health care and, in particular, adverse events—injuries suffered by patients as a result of their care.[1] Many adverse events are attributable to medications, and a substantial number, to medical errors.[2] The increased use of information technology—computerization of all ordering, pharmacy systems, bar coding, and event monitors—has the potential to improve quality and reduce errors.[3] However, there has been little evaluation of these technologies, with the exception of computerized physician order entry (CPOE), which a number of studies have shown to reduce the rate of certain types of medication errors.[4]

In response to concerns with patient safety and evidence of CPOE's efficacy, two organizations created mandates for hospitals to use this technology for the ordering of medications. The California Senate passed a bill requiring urban hospitals to implement, by January 2005, a plan to reduce medication errors, addressing "technology implementation, such as, but not limited to, computerized physician order entry."[5] The Leapfrog Group, representing many large employers, announced that the use of CPOE was to be a measure of "hospital recognition and reward."[6]

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In this paper we examine the evidence that CPOE can reduce medication error rates and otherwise improve the quality and cost of health care. We describe the current use of CPOE and the barriers to its further adoption. Finally, we examine the likely consequences of these mandates and recommend further actions needed to make the best use of this technology to improve quality and reduce costs.

Computerized Physician Order Entry

The ordering of diagnostic tests, medications, patient care, and referrals are important elements of patient treatment. We define CPOE as the direct entry of these orders into a computer by a physician or other authorized prescriber such as a nurse practitioner (in some instances, a medical student or nurse may initially enter the order, and the physician signs off the order before it is acted upon).

The advantages of CPOE over paper-based methods include decreased transcription, increased accuracy and completeness, and the ability to enter orders in multiple locations.[7] Most importantly, the use of CPOE makes it possible to deliver decision support to physicians at the point of care. This requires the decision-maker directly to interact with the computer.

Decision support can be used in CPOE to reduce the medication error rate and increase clinically appropriate and cost-effective ordering of medications and tests (Exhibit 1). Providing decision support requires the necessary data to be available in the computer system and the building of local consensus on the knowledge base and rules.

EXHIBIT 1
Clinical Decision Support Applied To The Ordering Of Medications And Tests

Objective	Example
Reducing medication errors	Drug name checking Drug dose, administration route, and frequency checking Drug allergy checking Drug-drug interaction checking Drug dose recommendations based on patient's renal or hepatic function Structured entry templates
Promoting clinically appropriate choices	Electronic access to clinical reference databases and medication guidelines Prerequisite or subsequent test recommendations (for example, drug levels) Duplicate order checking Disease- or problem-based medication and test order sets and recommendations
Promoting cost-effective choices	Substitute medication or test recommendations Display of recent test results Duplicate and redundant test checking Listing of medications by hospital or health plan formulary

SOURCE: Authors' analysis.

In studies at Wishard Memorial Hospital, physicians using CPOE generated lower costs, increased ordering of corollary orders (for example, a gentamicin level after gentamicin is ordered), reduced overall test ordering, and increased use of preventive care interventions compared with control groups.[8] At LDS Hospital the use of CPOE for antiinfective agents reduced adverse drug events and improved the use of agents that were appropriate to the infecting organism.[9]

At Brigham and Women's Hospital the use of CPOE reduced serious medication errors by 55 percent in one study and reduced all errors (excluding missed doses) by 81 percent over four and a half years in another study.[10] In the second study, dosing errors initially increased because of problems with the ordering of intravenous potassium, but this was subsequently rectified. Prescribing practices, such as the use, dose, and frequency of a recommended drug, have been improved with the use of CPOE at this hospital.[11] Studies of CPOE's ability to improve the use of diagnostic tests have produced both positive and equivocal results.[12] Finally, a systematic review of studies of computerized decision support found improved clinical care in nine of fifteen studies on computerized drug dosing.[13]

Diffusion Of CPOE In U.S. Hospitals

In a 1998 survey 17 percent of the 633 responding hospitals had partial availability of CPOE, and 15 percent had availability throughout the hospital.[14] More than half of the hospitals with CPOE reported that less than 10 percent of all orders were computerized and that less than 10 percent of medical staff used the system. Only seven hospitals (1 percent) had more than 90 percent of orders computerized and more than 90 percent direct physician use. In a 1999 survey 13 percent of the 539 responding hospitals had computerized ordering of medications.[15] In 93 percent of these hospitals, a pharmacist was entering at least 75 percent of orders.

Examples of comprehensive use of CPOE include Wishard Memorial and Brigham and Women's Hospitals, where the systems have been internally developed since the 1980s and 1990s, respectively.[16] Nearly all orders on inpatient units and a large proportion of medication orders in ambulatory clinics are directly entered into the computer by physicians in these hospitals. Queens Medical Center, using a commercial system, and the Veterans Affairs (VA) Puget Sound Health Care System, using the VA Computer Patient Record System, implemented CPOE for all orders on inpatient units in just two years during the mid-1990s.[17] At both sites physicians directly enter two-thirds of all orders.

At these four sites CPOE is used for all types of orders on inpatient units (tests, medications, patient care, and referrals) so that physicians are not burdened by separate ordering processes. Furthermore, many other functions are available on the computer, including computerized patient results and notes. Resident physicians typically enter all or most inpatient orders at these sites, although at Queens Medical Center nonstaff attending physicians enter most orders. Physicians dislike the extra time taken with CPOE, but they value the ability to enter orders

from any location and the ease of use of preset orders for common conditions. Physicians also report that the decision support in CPOE improves the standard of care. At LDS Hospital most physicians still use the anti-infective agent ordering system to guide their choice of agents but do not use it to order. Physicians also enter some blood orders, but nonmedical staff enter most other orders.[18]

In all of these facilities, implementation has been achieved with high-level leadership, long-term commitment of resources, extensive training and support, and involvement of physicians and other clinicians.

Barriers To Adoption Of CPOE

There are many barriers to the adoption and use of computer applications in health care. More than twenty years ago these were identified as lack of involvement by clinicians, inadequate long-term financial commitment, poor planning and implementation, substandard functionality and reliability of the technology, and lack of standardization of medical terminology.[19] Unfortunately, many of these barriers persist today.

■ **Physicians' work practices.** There are sociological barriers to CPOE, including changes in physicians' work practices, particularly the increased time that it takes to enter an order.[20] The organizational impact of CPOE systems and the commitment, effort, and resources required to implement these systems are great.[21]

■ **Current level of technology.** Another barrier is the current level of information technology in health care. Health care has long underinvested in information technology compared with other industries, and most hospitals rely on legacy systems designed to support administrative functions.[22] Even in hospitals with extensive clinical information systems, the data are spread across numerous systems using different technology and terminology standards.[23] For CPOE to be effective, such applications must be integrated.

■ **Status of commercial systems.** Yet another problem is the status of commercial CPOE systems.[24] Most of the leading CPOE systems now in place are "home-grown," although most hospitals without the resources to develop their own systems will need to purchase vendor-built systems. None of the commercial systems available appear to provide the functionality of the best home-grown systems. This should soon change, but it will require partnering between delivery systems and vendors. Two recent reports give an overview of commercial CPOE systems and indicate a recent increase in the number of systems available in the marketplace.[25]

■ **Lack of financial incentives.** A crucial remaining barrier to CPOE is the lack of alignment of financial incentives for organizations to adopt the technology. The cost of implementing CPOE depends on many factors, but it is on the order of millions of dollars.[26] However, the cost savings of using CPOE may not accrue to physicians and hospitals under current reimbursement arrangements. In a fee-for-service environment, reducing hospital lengths-of-stay by avoiding adverse drug events or reducing the number of tests ordered may have a negative impact on hospital fi-

nances. Even in a prospective payment or capitated environment, the investment required can be hard to justify when there are powerful short-term cost pressures and the benefits are unsure and occur in the medium to long term.

Diffusion Of Technology

The attributes of a new technology that are important in determining its rate of adoption are described by the Diffusion of Innovation Theory.[27] A new technology's relative advantage, compatibility, trialability, and observability generally lead to a faster rate of adoption, while increased complexity leads to a slower rate of adoption. The decision to adopt CPOE is a two-step process: First, the hospital must decide to adopt, and then the individual physician must decide whether to use it. The different perceptions of hospitals and individual physicians toward CPOE are important, because it is the perceived rather than the actual attribute that determines adoption (Exhibit 2).

Mandates may exert pressure on potential adopters to accept the advantages of CPOE systems. Incentives can increase the relative advantage of CPOE and may

EXHIBIT 2
Attributes Of Computerized Physician Order Entry, As Perceived By Providers

Attribute	Perception of hospital	Perception of individual physician
Relative advantage (What are its benefits compared with current methods or technologies?)	Positive Decreased errors Reduced costs Status Negative Large initial investment	Positive Decreased errors Easy access to clinical reference sources Ability to enter and view orders in multiple places Negative Increased time
Compatibility (Is it consistent with existing values, experiences, and needs?)	Positive May fit with experience of computerization in other parts of hospital Meets need to lower costs and comply with mandates	Negative Large change in behavior Potential challenge to autonomy
Complexity (Is it difficult to understand and use?)	Positive Just another computer system	Negative Complex compared with paper ordering system
Trialability (Can it be tried out on a limited basis?)	Positive May be piloted in single units Negative Difficult to try without investment	Negative May consider an all-or-nothing proposition
Observability (Are the benefits readily observable?)	Positive May be willing to accept publicly stated benefits	Negative May need further convincing of benefits

SOURCES: E.M. Rogers, *The Diffusion of Innovations,* 4th ed. (New York: Free Press, 1995); and authors' analysis.

trigger the adoption decision. They also may induce early adopters of CPOE to increase its observability to others. Incentives can be financial but also can be anything of value, such as increased status. Finally, incentives may induce hospitals to adopt CPOE merely to obtain the incentive, and they may fail to adequately implement the technology and sustain its use over time.

Promoting Further Adoption Of CPOE

An important and growing body of evidence shows that CPOE can reduce medication error rates and can influence physicians to order medications and tests in a more clinically appropriate and cost-effective manner. The mandates issued by the California Senate and the Leapfrog Group appear to have stimulated the market to increase the number of commercially available systems, as well as to increase the number of hospitals wanting to implement CPOE in the next few years.[28] However, their impact on the adoption of CPOE will be blunted unless insurers or patients selectively choose hospitals and physicians based on its use.

Given the current low diffusion of CPOE, it may be ambitious to simply require its use. We propose a more comprehensive model to increase the adoption of CPOE and ensure that its use leads to improvement in quality and cost: (1) incentives to promote adoption; (2) further research into the benefits and factors associated with successful implementation; (3) development of guidelines for implementation; and (4) development of common measures to assess its impact.

■ **Providing incentives.** It has been shown that the profitability of a new surgical or diagnostic technology is a strong incentive for its adoption by hospitals.[29] Providing financial incentives will similarly increase hospitals' adoption of CPOE. These incentives could be part of an overall plan to improve quality through the increased use of information technology. The British National Health Service (NHS) has a plan for investment in information technology, and in Australia a coordinated national approach including incentive funding has led to 67 percent of primary care practitioners' reporting use of computerized prescribing.[30]

Two bills before the U.S. Senate would provide grants to hospitals and skilled nursing facilities to implement information systems designed to improve medical care and reduce errors.[31] The Health Information and Quality Improvement Act of 2001 would provide $420 million, and the Medication Errors Reduction Act of 2001, nearly $100 million, annually for the next ten years. The first bill proposes that the Agency for Healthcare Research and Quality (AHRQ) provide advice on selection of systems and evaluate the impact of the program. The fate of these bills will be a good indicator of the federal government's commitment to promoting this technology.

It is unlikely that employers and insurers will provide direct capital funding for CPOE. A differential reimbursement scheme to reward hospitals and physicians using CPOE might be difficult to implement but could be effective. The use of selective contracting with providers using CPOE is the most likely approach from

these parties. The Leapfrog Group is providing lists of hospitals using this technology to patients and payers.[32]

■ **Research and guidelines.** Incentives may induce hospitals to adopt CPOE but may not be sufficient to convince physicians to use it. Additional research to make the benefits of CPOE more observable will improve physicians' perceptions, but getting them to use it is ultimately up to leadership at individual hospitals.

Hospitals need to minimize the additional time burden imposed by CPOE use. This can be achieved by ensuring that systems have fast response time, allowing physicians to enter all orders on the computer at one time, providing order sets (predetermined lists) for common conditions, and introducing computerized systems that allow physicians to also view patient results and notes. Where applicable, CPOE use could be built into physicians' performance bonuses as a quality improvement activity. Physicians must be involved in developing the rules and knowledge base of the decision support contained in CPOE, or they may reject attempts to modify their ordering behavior. Hospitals may need to allow physicians to try CPOE and must provide adequate training and support.

More research is needed into implementation factors and to develop guidelines to help hospitals implement this technology. Another approach would be for hospitals that have CPOE to act as mentors for new adopters. There is a need to develop common measurement criteria to assess whether the adoption of CPOE leads to improvements in quality and cost. These criteria should include the level of physician entry of orders and an assessment of each CPOE system's ability to detect and provide alerts for a standard set of ordering scenarios or the number of medication errors prevented by the system. Vigilance to ensure that CPOE does not introduce new errors is also necessary.

■ **Assessing CPOE's impact.** AHRQ has considerable experience in funding research into patient safety and information technology and thus is a logical entity to oversee further research into the impact and implementation of CPOE.[33] However, the funding of this research needs to come from both public and private sources. Professional organizations and commercial vendors must continue to develop standards for technology and clinical nomenclature and for minimum requirements.[34] The American Medical Informatics Association could coordinate the development of guidelines, standards, and measurement criteria.

Although they have their own limitations, pharmacy systems are an alternative method of identifying medication errors after they have occurred but before the medication is administered to the patient.[35] However, because the decisionmaker is not directly receiving the alerts and reminders, the process of notifying the physician to change the order is resource-intensive, and there is little or no opportunity to influence clinically appropriate and cost-effective choices.

CPOE is not a panacea, but it does represent an effective tool for bringing real-time, evidence-based decision support to physicians. Governments, employers, and the community must realize that without a coordinated plan to encourage

CPOE adoption and evaluate its impact, adoption of this technology by hospitals and physicians will continue to be slow.

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NOTES

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