Computerised practitioner order entry over the last decade: progress and unsolved problems

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Summary
Over the last decade, CPOE has become more common but remains limited to a minority of U.S. hospitals and clinics. Most organisations with CPOE now are using commercially developed CPOE systems, using vendors with more experience with larger numbers of customer sites. The software itself is more mature, no longer regarded as experimental, and is often accompanied by commercial offerings for order set content, development tools, and content maintenance contracts. Physicians no longer regard CPOE as unusual, particularly those who have recently completed training in an academic medical centre.

CPOE user interfaces are remarkably similar between vendors, and have not dramatically departed from metaphors and screen designs used in early CPOE systems. They require hours or days of training before practitioners begin using them for patient care, and differ sufficiently between vendor so that practitioners must sometimes be trained separately on several systems if they practice in several hospitals. We know surprisingly little about how to best use the CPOE tool to modify practitioner behaviour using decision support tools.

CPOE then, is no longer new, but in need of renewal. Clever ideas and breakthroughs are overdue. Clinical, safety, and financial benefits can be achieved with CPOE (despite evidence they can also harm), but it is likely that much more benefit awaits us in the decade to come.

Introduction
It has been 13 years since Sittig and Stead’s pioneering review of computerised practitioner order entry (CPOE) in the second issue of the Journal of the American Medical Informatics Association, describing experience with early CPOE sites including the advantages and difficulties of these systems [1]. Much of what they described was based on institutions using systems developed internally, though some commercial systems were also in use. In 1998 a report from the Brigham & Women’s Hospital in Boston was published in JAMA, showing large reductions in serious adverse medication events with CPOE [2], followed by publication of the Institute of Medicine book To Err is Human in 1999 [3]. CPOE became a topic not just in academic and informatics literature but in the popular press.

Purchasers and patient safety organisations, encouraged by the published experience, lobbied for faster adoption of CPOE, a movement supported by many informatics experts and the health information technology industry. The term CPOE and the demand for it were commonly heard in U.S. national discourse.

CPOE systems more commonly used in the United States
Over the last decade, many community hospitals and clinics have adopted commercial electronic medical record systems including CPOE. CPOE is quite common in large urban medical centres, academic medical centres, (EMR) and in large community hospitals. Commercial vendor electronic medical record applications typically include CPOE as a key component of their offerings. Use of CPOE has extended from inpatient medical and surgical units to critical care units, paediatric hospitals and the outpatient setting. Remote entry of orders is a popular option with physicians, and the ability to modify physician ordering behaviour to follow organisational guidelines [4] and adhere to institutional formulary choices makes CPOE popular with hospital administration. Patient safety advocates include CPOE among the tools they promote to reduce errors and as part of campaigns to improve safe care.

Medical students, residents, fellows, nursing students, and other healthcare trainees often receive part of their training in an academic institution that uses CPOE, and begin their practices familiar with CPOE and with the expectation that hospitals and clinics where they will practise have it installed.

The healthcare information technology vendor community has embraced interest in CPOE, and in electronic medical record adoption more generally. Reference to adoption of electronic medical records has appeared in U.S. presidential State of the Union messages, along with the goal that most Americans receive care using EMRs within a decade. Membership of the Health Information Management Systems Society (HIMSS) has grown tremendously, and the annual meeting is now one of the largest assemblies in the United States. Stock price of publicly-traded healthcare IT companies has risen in many cases, though the field remains highly competitive and some firms have dissolved or been purchased by competitors. As a marker of growth of healthcare IT, in my city there are now...
posters on public buses advertising careers in informatics. However, installation, configuration, training, and support of CPOE remains a difficult and expensive endeavour despite its advantages, and thus, according to a survey conducted in 2002 [5], in the United States most orders entered for patient care are still written on paper. Despite growing health care expenditures, many health care organisations have little margin or profit and insufficient resources for large initiatives such as implementing CPOE. Though physician resistance is frequently cited as a major barrier, it is often cost that is the main barrier to CPOE adoption.

In an effort to increase adoption and defray the expense of CPOE installation, there have been a variety of programmes to assist small physician practices and hospitals with the cost of installation. Changes in U.S. laws have partially relaxed anti-kickback legislation to permit hospitals to pay a portion of the cost of electronic medical record system installation. Grant programmes help with initial expense of EMR implementation. However, in the U.S. most practices still bear the cost of CPOE installation and maintenance, and this remains a large barrier to adoption.

Increasing sophistication in some areas
CPOE systems have grown in breadth of use and functionality from the simpler systems used in pioneering sites. As fundamental functionality has been improved, CPOE now better fits into clinician workflow rather than existing as a separate, stand-alone application. The electronic order for a medication, laboratory test or other service is a building block joined with other parts in a larger whole.

Preconfigured orders and order sets
The entry of an order can involve myriad smaller decisions often not specified in paper orders, such as when a blood test should be collected, tablet size, or which CT scan protocol. Before CPOE was available, someone made each of these decisions sometimes by default, but CPOE made it possible to move many of these choices to the ordering practitioner. Sometimes asking the ordering physician to make each decision was warranted, but often a set of choices bundled together satisfied the need. These bundled choices were then implemented as preconfigured orders, called different names by CPOE vendors [6]. In effect, the ordering practitioner can choose either to begin an order using a preconfigured order which saves time and complies with what the filling department expects, or start the order from the very beginning. The time-savin...

ing features of preconfigured orders are popular among practitioners, and most organisations created hundreds or thousands of these when preparing to implement CPOE.

The next step was to collect these preconfigured orders into groupings corresponding to a clinical need or scenario. These groupings are often called order sets. Order sets for elective surgery, hospital treatment of pneumonia and many other scenarios are popular with practitioners again because they speed the ordering process; and they are popular with organisations because they make it easier to follow organisational guidelines embodied within these order sets [7]. Most successful CPOE sites have developed large collections of order sets. Some sites have not created order sets; some of these sites have encountered physician resistance that can be traced back to the increased time requirement for entering a large number of separate orders.

Plans of care
CPOE vendors have extended CPOE to support plans of care, which are preformulated, linked orders and data collection steps designed for use during a clinical scenario such as elective surgery or treatment of a malignancy. They embody the sequence of steps over many visits, sometimes with conditional logic, that is used to link individual orders and order sets together. This offers an additional tool to reduce unwarranted variation in managing common conditions, and can make variation explicit and analysable.

CPOE has matured, then, from merely making it possible to communicate an order to a filling service electronically to the current state of supporting management of complex patient scenarios such as a course of chemotherapy.

Integration with documentation and results review
Provider workflow of course includes more than communicating orders. Documenting what has occurred and what is planned remains an important foundation for clinical care, but is now sometimes the basis for reimbursement for that care. For these and other reasons, attention of EMR developers is shifting to support of documentation, and in integrating the ordering process into the larger context of patient care workflow. Orders are written after review of the latest patient results, updating the history and physical examination and creating a document. Some vendors make these processes efficient by permitting orders to be written while writing a note, and conversely by including recently written orders in the next progress or clinic note. All of this must be accomplished quickly and efficiently and with minimum training requirements. CPOE application development is best accomplished in close connection with those de-
Rules and decision support

A compelling rationale for CPOE is that it permits bringing decision support into the ordering process, where advice can be seen and acted on by the ordering practitioner. To accomplish this, sites create rules and ordering aids that prompt the ordering clinician to enter safe, efficient orders most likely to benefit the patient. Creating, collecting, maintaining, and using these rules so that they are brought to bear when needed during the ordering process and afterwards is an extremely challenging area for informatics. The field of decision support is broader than CPOE, but the golden moment when orders are formulated and before they are signed is a key opportunity for modifying decisions with automated tools. Simple rules and pop-up dialogue boxes remain effective but CPOE systems now include other ways to bring information to the clinician attending during the ordering process. Anticipatory alerts visually suggest orders to avoid or preferentially select; some information is not presented during the act of ordering but proposed immediately afterwards in a fashion known as corollary orders [8]. Others in the health care team may receive and act on orders before the physician encounter begins—this division of labour is often more efficient and better received by patients and providers than overwhelming the practitioner with prompts and alerts during a short visit. Sophisticated frameworks for creating decision support have been developed and tested; some have not yet reached broad use but offer models for future production systems.

Inpatient and outpatient care

Many of the earliest, well-known papers on the value of CPOE were based in the hospital, yet people receive most of their care outside the hospital. The pace of ambulatory care work is different from hospital rounds, and a great deal of attention has been shifted to CPOE in the clinic setting. Some vendors began their CPOE application business by targeting the clinic setting, and others have migrated their applications there. Handheld devices, some specialised for medication ordering, are appealing to many practitioners while other CPOE systems are linked to the comprehensive EMR. Much progress has been made in linking CPOE to pharmacy benefit management systems and to networks used by community pharmacies to track and authorise prescription refills. The merging of pharmacy data from pharmacies and health care delivery organisations holds promise but has not yet been widely achieved in the United States. The drivers to do this include a better understanding of compliance based on numbers of refills actually given, and the labour-saving potential both to practitioner offices and pharmacies if paper and fax communication can be replaced with electronic review and authorisation of refill requests within a CPOE system.

Fundamental problems remain

Despite enormous progress in CPOE over the last decade, it is also surprising that many fundamental problems remain unsolved. Addressing these problems may be the key to broader adoption of CPOE, with accrual of the clinical and operational advantages to CPOE that this will make possible.

User interface

With some notable exceptions the user interface used in CPOE systems is very similar today to the way it appeared a decade ago. Dialogue boxes, drop-down menus, radio buttons and scroll bars were first introduced to most users in the 1980s, and while it is possible that these user interface metaphors are ideally suited to human behaviour, it is also possible, and even likely, that much better user interface options exist. Vendor CPOE applications are remarkably similar to each other (but not so similar that users moving from one hospital to the next can forgo hours of training), and advances in the overall user interface are modest. Most vendors recommend hours or even days of training before orders are written, and sometimes the user interface is so confusing that potentially dangerous errors can occur. Breakthroughs in computer user interface design are rare; it may be that fundamentally new approaches to CPOE application design would reduce training requirements, increase ordering speed, and increase safety. CPOE applications differ from most other computer applications because they are used to order potentially dangerous medications and are used in the highly complex healthcare setting. Designing, testing and implementing CPOE systems remains extremely difficult, and so the conservatism and gradual pace of improvements by vendors is understandable. Developers deserve respect for the difficult design task they face.

Matching workflow

Though CPOE developers have made considerable progress in tailoring results review, CPOE, documentation, PACS review and other tasks to practitioner workflow, each of these applications is often developed by a separate development team and this is apparent to users. Rapid hospital rounds in which 30 patients may be seen in 90 minutes, with the expectation that new data is digested, orders are written and notes signed before moving to the operating room at 7 a.m., is
a challenging workflow to accommodate, particularly with requirements for infection control, traversing many hospital floors, privacy requirements and constant interruptions. Most clinicians feel that their workflow is not given adequate consideration by CPOE vendors, and that they need to modify their working methods to meet the needs of the application rather than vice versa. If there were an ideal workflow agreed to by all it would make CPOE development easier to accomplish.

**Performance**

Rarely do practitioners feel that entering orders is as fast as it should be [9]. Their previous standard was the time required to write an order on a piece of paper for others to interpret and communicate. Some of the additional time requirement is to find a workstation, log in, and select the patient, but some is the time spent waiting for screens to appear or refresh. Some of this time can be recouped using order sets or batching orders together, but despite these strategies the most common complaint heard from practitioners regarding CPOE is that the additional time required. Software design, hardware sizing and configuration, and other strategies can help, but these advances are balanced by demands for new functionality that in turn harms performance.

**CPOE disadvantages a surprise to some**

Early papers on CPOE highlighted the challenge of designing, implementing, and using CPOE successfully. Gradually the literature reported successes achieved after implementing CPOE, leading to well-known studies showing the potential to improve medication safety. Most of these articles also pointed out the difficulty and challenge of CPOE implementation, but these cautionary paragraphs were not given as much attention as the positive results. When papers appeared showing that CPOE applications are used in ways for which they were not designed [10], this was received as a surprising finding, especially by those who had not been involved in CPOE development and installation. A paper described association of CPOE implementation — along with many concurrent interventions — with a rise in mortality for a subset of patients, along with details of the implementation [11]. The literature of “unintended consequences” [12] surprised some, but not those who have seen implementations first-hand. The pendulum swung from a series of articles highlighting advantages to reports that CPOE can cause harm. This potential for benefit and harm is shared by many other powerful healthcare interventions. On balance, most organisations have chosen to retain CPOE after installation, evidence that in their judgment the benefits outweigh the risks.

**Concern about over-alerting, but little data**

Many CPOE sites have reported that the rate at which providers override alerts they see while entering orders is high [13, 14]. Most authors comment that these rates seem higher than ideal, and some propose what the rate would ideally be. The concern is that, if alerts intended to avoid orders that may harm patients are mixed with many other alerts that are regarded as clinically irrelevant, important alerts may be missed. However there are no data to suggest what the ideal override rate should be. In fact some have commented that alert override rates may not be a valid measure of alert effectiveness, because after seeing the alert the ordering practitioner may order more careful monitoring even though the alert is overridden. The phrase “alert fatigue” appears frequently, yet a clear demonstration and documentation of its effects is not yet available. High override rates also suggest that there may be more effective methods to guide ordering behaviour than a pop-up dialogue box that interrupts ordering work. There is also interest in improved tailoring of knowledge bases used to generate alerts, limiting alerts to those regarded as most helpful. Commercial databases and knowledge sources are under scrutiny for this reason, but also for their value to CPOE more broadly.

**Commercial options for configuring and maintaining CPOE**

Early reports of the substantial effort required to create preconfigured orders, order sets, and other order collections, mixed with evidence that providers appreciate order sets, led entrepreneurial organisations to offer aids to order configuration. Existing health information publishers and entirely new organisations have begun offering order sets to organisations preparing for CPOE. Even sites that have successfully implemented CPOE understand that maintaining order configurations is a prodigious task. In fact, over a decade most time devoted to CPOE by organisations is not in the go-live but in continuous review and maintenance of order sets, electronic plans of care, and even individual preconfigured orders. Some organisations offer editing tools that link with commercial CPOE systems and permit sites to take advantage of the vendor’s expertise in culling the literature for best practices and converting them into selectable options within CPOE. This market for “actionable knowledge” and tools to create it within a CPOE system is new, and may grow.
Pressure from payers now diluted to include much more than CPOE

Following publication of “To Err is Human”, healthcare purchasers in the United States encouraged hospitals in their communities to adopt CPOE along with other measures to improve patient safety. The Leapfrog Group, a consortium of healthcare purchasers, selected three measures they referred to as ‘leaps,’ including CPOE, evidence-based referrals, and full time intensivists in ICUs [15]. They scored healthcare organisations in many U.S. markets using a public website. Subsequently they have added many other leaps and thereby, perhaps appropriately, placed CPOE in perspective as one of a large number of measures hospitals can adopt to improve healthcare quality and safety. Though pressure on hospitals from Leapfrog continues, pressure to adopt CPOE is consequently diluted by inclusion of an increasing number of measurement criteria. Other organisations focused on increasing healthcare quality and safety have, while often encouraging CPOE, added many other measures to the list they recommend hospitals adopt.

CPOE then, is no longer new, but in need of renewal. Clever ideas and breakthroughs are overdue. Clinical, safety, and financial benefits can be achieved with CPOE (despite evidence they can also harm), but it is likely that much more benefit awaits us in the decade to come. Formulary choices makes CPOE popular with hospital administration. Patient safety advocates include CPOE among the tools they promote to reduce errors and as part of campaigns to improve safe care.

References