Computerized Physician Order Entry: A Disruptive Technology?

Innovations can improve care, convenience and cost effectiveness

Healthcare must be open to changing technologies and business models that are likely to threaten the status quo if the innovations will ultimately raise the quality of healthcare.

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Computerized physician order entry (CPOE) must be disruptive. Yet the word "disruptive" in this context has multiple meaning. Most readers will read "disruptive" and envision the imposition of CPOE and see their comfortable work patterns thrown to the wind. CPOE will disrupt the ability to call in, and/or just bark, verbal orders. Common fears are that CPOE requires more time; is inappropriately inflexible; alters traditional communication channels; and even changes the thought process of physicians. For example, an idea for an order is often generated at the bedside and may be altered or lost by the time a physician finds a computer, signs on, navigates the software and finally enters an order.

That is not the intended meaning of the word disruptive in this context. In an insightful *Harvard Business Review* article titled, "Will disruptive innovations cure health care?" Christensen, Bohmer and Kenagy observed, "Health care may be the most entrenched, change-averse industry in the United States." The authors argued healthcare must be open to disruptive technologies and business models that are likely to threaten the status quo in order to ultimately raise the quality of healthcare.

Both "small" innovations and "large" innovations can be disruptive, but they bring higher-quality care far more conveniently and cost effectively. Consider, for example, portable glucometers that replaced expensive centralized laboratory equipment and the emergence of shopping mall based nurses to triage and treat common medical problems.

As time progresses, any technology or process will improve its performance. Initial consumers are, by nature, the least demanding and will use, for instance, a CT scanner with grainy images that require 20 minutes to acquire. Over time, performance improves—the CT scanner develops images in 10 minutes—and more consumers adopt the technology.

Eventually, performance improves beyond the requirements of even the most demanding consumer. Any further performance enhancements of this specific technology is worthless. At this point if anatomic imaging is to improve, a disruptive technology must surface and the performance-time cycle repeats.

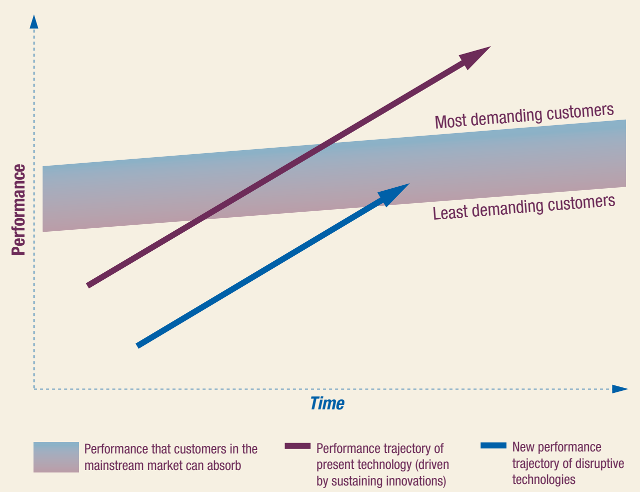
Paper-based order-entry systems even with their current enhancements (e.g. protocols) should not be further enhanced. Rather, the disruptive order entry innovation (CPOE) has moved off the old paper-based development trajectory to a new one. At the moment, performance is to the point where the early adopters have implemented systems and are beginning to report their experiences. As time has passed and CPOE performance has improved, the "mainstream" institutions are now implementing CPOE.

So again, is CPOE a disruptive technology? Of course. Will CPOE bring higher quality? Most physicians believe so. CPOE has been convincingly shown to reduce adverse drug events.[1] Many prominent organizations, such as the Institute of Medicine and the Leapfrog Group, have called for the broad implementation of CPOE solutions. In an analysis of quality then translated into dollar savings, the Massachusetts Technology Collaborative suggested that if 75 percent of Massachusetts hospitals and outpatient facilitates implemented CPOE, the Commonwealth would save in excess of $1 billion a year.[3] The projected savings break down into the following categories:

E-prescribing	**$140.7 million**
Ambulatory CPOE	**$390.3 million**
Acute CPOE	**$966.0 million**

These savings, in part, result from CPOE's convincing ability to reduce adverse drug events.[1,4] However, as CPOE moves into the hands of more demanding users, it is the focus of intense scrutiny to understand its roles within the broader context of provider workflow and medical error reduction.[5,6]

The Progress of Disruptive Innovation



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Dominant players in most markets focus on sustaining innovations—on improving their products and services to meet the needs of the profitable high-end customers. Soon, those improvements over shoot the needs of the vast majority of customers. That makes a market ripe for upstart companies seeking to introduce disruptive innovations.

CPOE is not problem free

Certainly, CPOE is not completely problem free.[7, 8] Opinion,[9, 10] anecdotal,[11] and some observational data[7, 12] are beginning to emerge that draw attention to difficulties with CPOE.

Koppel et al studied the house staff at a tertiary-care teaching hospital using surveys, focus groups, and one-on-one interviews with the house staff as well as other leaders. They specifically sought to uncover medication errors that were caused or exacerbated by CPOE. They discovered 22 categories of latent or actual medication errors. Examples were incorrect orders facilitated by inflexible screens, fragmented display screens which led to incorrect understanding of a patient's current medication list, double-dosing and others. Seventy-five percent of the house staff reported observing each of the 22 error types.

Arguably, critical care has the most demanding workflow placing unique demands on CPOE systems. That is not to say the time-pressured environment of ambulatory medicine is not demanding, rather in critical care more orders are placed per patient per day and many orders must be filled within short time frames. Consequently, medication errors in pediatric and adult[13] critical care are diverse and may often be life-threatening.

An observational study of CPOE workflow in a 15-bed adult medical/surgical critical care unit yielded the following:[12]

- Given the idiosyncrasies of the CPOE implementation with only one computer at each bedside, physicians seldom entered orders there. Consequently, nurses had fewer bedside discussions of orders and plans.
- An additional cognitive burden was observed as the "idea" for orders was created at the bedside, but because orders were often placed at another site there was substantial opportunity for interruptions and distractions between the order "idea" and order entry.
- An individual order using CPOE took slightly longer to enter than a similar written order. Consequently, it was not possible to enter all the orders for a patient during rounds.

CPOE within pediatric critical care has been implemented as part of hospital-wide initiatives.[14] After a year-long preparation, these investigators showed a significant decrease in harmful adverse drug events (ADEs).[4] The reduction translated to the prevention of one harmful ADE for every 64 patient days.

Again, caution must be exercised as technology can introduce new errors.[9] Within the Veteran's Administration (VA) Medical Center in Salt Lake City, even after CPOE implementation, ADEs were documented at a rate of 70 per 1,000 patient days.[15] An even more recent study demonstrated a rise in mortality coincident with the implementation of CPOE.[8] Unlike the Koppel study, this study was not specifically designed to examine CPOE. Rather, an available dataset of patients transported into a tertiary children's hospital was retrospectively analyzed. In the 13 months before, and five months after CPOE implementation, unadjusted mortality rose 2.8 percent to 6.6 percent. The data has received intense scrutiny and the belief of most observers is the two facts are coincidental.

What is troubling in the effort to understand causality from these data is the difference in the pre- and post-CPOE comparison groups. Variability, particularly seasonal variability, is common in pediatric critical care. Yet, consistent with the observational study previously noted,[12] prolonged rounds as well as slower and more complex order writing during periods of high activity were perceived to hamper efficient care.

Other investigators documented significant improvements in patient safety within pediatric[16] and a neonatal critical care units (NICU).[17] The pediatric intensive care unit (PICU) study looked at all patients and orders in a two-month period both before and after implementation of CPOE. In total, 13,828 medication orders were reviewed. Medication prescribing errors dropped from 30.1 per 100 orders to 0.2 per 100 orders after implementation of CPOE. ADEs fell from 2.2 per 100 orders to 1.3 per 100 orders. In this study, the residual ADEs were believed to result from incorrect or inadequate patient-specific information available at the time an order was placed. Errors involving dose and interval also showed no significant difference between the pre-and post-CPOE periods. The NICU study looked at more focused outcomes and showed that time was reduced significantly between order placement and drug administration as well as between order placement and radiograph image delivery. Gentamicin errors, a source of substantial neonatal nephrotoxicity and ototoxicity, were eliminated.

Decision support is critical to the success of CPOE. As a prelude, the VA study documented zero transcription errors, but 61 percent of the ADEs were initiated in the ordering process.[15] The authors concluded ADEs will continue to occur in systems that lack decision support. In contrast, Upperman et al from Children's Hospital of Pittsburgh[4] said, "We believe that these gains [decreasing harmful ADEs] were because of 'rules' that are built into the system." Since publication of this article, the following continue to be observed within the same facility:[18]

- Patient weights are entered 100 percent of the time
- Weight-related ADEs are practically eliminated
- Allergies are entered for more than 99 percent of patients
- Order information is completed in full 100 percent of the time
- Transcription errors and legibility questions are completely eliminated

Culture and implementation: CPOE is more than technology

It is said that culture eats strategy and technology for lunch. Culture was responsible, in large part, for the widely publicized failure of a CPOE system at the Cedars-Sinai Hospital in Los Angeles. On an encouraging note, recognition of the need for change management[14] allowed the Children's Hospital of Pittsburgh to achieve positive results as well as to adjust to the lessons learned from their critical care experiences.

Formerly "Disruptive" Technologies

Microscope	Invented 1590 by Dutch lens grinder Zacharius Janssen, refined 1670 by Anton van Leeuwenhoek
Vaccines	1796, Edward Jenner pioneers means of protecting people from smallpox via exposure to cowpox
X-ray	1895, Wilhelm Röntgen
Antibiotics	1928, penicillin by Sir Alexander Fleming
Cardiac Pacemaker	1952, Paul Zoll
Kidney Transplant	1954, Dr. Joseph E. Murray
Home Pregnancy Test	1976, e.p.t.
MRI	First commercial scanner produced March 1980

Source: www.infoplease.com

There are a number of well recognized steps in the lengthy process which must precede CPOE "go-live." Foremost, a sense of urgency must be cultivated at multiple levels within the organization. Motivators will differ by institution, department and role. Motivators, such as patient safety, may be common. They may be role specific, such as workflow improvement for house staff and task integration for nurses. Cultivation of the same sense of urgency in senior leadership is crucial. Chief medical and nursing officers must be genuinely engaged because "partial" engagement will be seen by everyone as a license to be similarly engaged.

Second, if all that CPOE accomplishes is the codification of the current paper-based (error-prone) processes, people will only be maimed and killed with better efficiency. Implementation of CPOE is best viewed as an opportunity to re-evaluate a myriad of customary workflow decisions:

- Are verbal orders really necessary? If verbal orders are necessary, how often and in what circumstances should they be accepted?
- Can decision-support tools be used to supplement or replace current controls for expensive or otherwise controlled drugs?
- Can the pharmacy change orders to correct formulations or schedules? If pharmacy can modify orders, must the original prescriber co-sign the order or just be notified?
- Are pre-mixed concentrations to be used for most continuous infusion medications?

In short, no paper-based ordering processes should be left untouched. That is not to say all paper-based processes must change. They must be re-examined.

Third, a CPOE governance structure must be created. Because a CPOE effort is best launched by senior executives, a senior cabinet should set the broad priorities and monitor the culture change, design/implementation and roll-out. A clinician-advisory committee must assume responsibility for definition of physician and nursing order bundles. The clinician committee should also assume responsibility for the examination and modification of the order workflow processes. Further, there must be CPOE champions in each of the divisions within the institution. If there are four intensive care units, there must be one champion from each. It is the role of the champion to serve as a liaison between the clinician advisory committee and the "front line." Leading must be by example. The example set by the unit champion is crucial, as it is the most visible.

Finally, there must be a technical advisory committee because much also rests on the skillful implementation of these computer systems.

Creation, implementation and maintenance of rules

Although it is hard to choose the most important aspect of a CPOE implementation, creation, implementation and maintenance of rules qualify as the most crucial steps. Rule creation can not be only a job for the cabinet, the clinician advisory committee or the divisional champions. Everyone must feel responsible for the rules. It is with the careful application of rules that many adverse drug events will be caught and avoided.

Rules can be as simple as the presentation of a field within a CPOE window that requires the input of allergies and body weight before allowing an order to be placed. These fields can be automatically populated by available data, but force the user to acknowledge before proceeding. Other examples of required fields and/or processes are the demand for a second signature when ordering specific drugs (e.g. digoxin in children or chemotherapy) or demanding a second signature at the time of drug administration (e.g. blood products). These so-called synchronous rules have been shown to decrease the inappropriate use of drugs in patients with renal insufficiency.[19] Improvements previously mentioned in allergy checking and weights available for dose checking are also examples of synchronous rules.

A second type of rule, asynchronous, is one that triggers some time after an order is placed. An example is a rule that continuously looks for laboratory evidence of renal dysfunction in the setting of a patient on a nephrotoxic drug.

Training, and lots of it, is crucial to the success of a CPOE go-live. Even in a scenario where the staff is uniformly computer literate and the CPOE software is completely intuitive, training is necessary. The process changes must be communicated. The order bundles must be explained. The rules must be understood.

A common effective strategy is to train a few "super-users" within each division. Not only will they be available to reinforce and extend the training received by all users, but their deeper knowledge of the CPOE system allows them to work faster and more efficiently. As such, super-users teach, but also lead by example.

Decision support

The full potential of CPOE will be realized when the right data is presented to the right person at the right time so the right decision is made, resulting in the optimal clinical outcome. Clinical decision support is at the heart of the CPOE promise. The field of medical decision support is at least 30 years old.[20-22] International conferences focused on computer-based decision support at least 20 years ago.[23]

The field of decision support was born not around CPOE, but rather around the need for consistent application of diagnostic criteria. One of the original computer-based decision support systems was DXplain by Octo Barnett and his colleagues at Massachusetts General Hospital.[24] DXplain and three other programs were compared to human experts with standardized clinical cases. All the decision support systems performed with similar accuracy. Correct diagnoses were suggested in approximately one-half to three-quarters of cases. The suggested diagnoses were irrelevant between 63 percent and 81 percent of the time. However, each of the four studied systems suggested approximately two additional diagnoses per case the human experts believed were relevant and they had not otherwise considered. A more recent survey showed that residents believed access to DXplain to be useful.[25] A solution focused initially on pediatrics has shown similar utility.[26]

Relevant to the rules and CPOE, an important updated meta-analysis of clinical decision support systems was published approximately one year ago.[27] The authors analyzed 100 studies of clinical decision support published through September 2004. In general, they believed the quality of the studies had improved from their earlier review.[28] The 100 studies were grouped into studies designed to support clinical diagnoses (10 trials), disease prevention (21 trials), disease management (40 trials) and drug prescribing (29 trials). The studies were evaluated to determine whether the systems improved provider performance. More important, the studies assessed whether they improved *patient outcomes*. It is in this latter category where the results remain disappointing; only seven of the 52 trials reporting on patient outcomes showed an improvement in a specific patient care outcome. The authors concluded that only two trial characteristics were correlated with improved practitioner performance: the authors of the trial wrote the software tested, and the decision support system was invoked automatically and interrupted the workflow. A second meta-analysis confirmed the second finding.[29]

Alert fatigue is another important emerging problem for which there is little data in the literature. In other words, well designed rules, if they fire in the midst of a barrage of minor and relatively useless rules, will get lost in the noise and become ineffective. A better known scenario associated with alert fatigue is the false-alarm rate inherent in bedside monitors. As many as 90 percent of threshold alarms announce either false alarms or "true" alarms but are clinically irrelevant.[31] Much work remains to be done to optimize the delivery of decision support solutions as a 90 percent false-positive rate will render a clinical decision support system worthless.

Conclusion

CPOE holds substantial promise to dramatically improve the care of all people who require medications and practices of all patient care providers

CPOE is at least one part technology and one part culture. Was the balance between technology and culture not equal, the 'heaviest' part is culture.

CPOE will be most successful with the implementation and maintenance of a comprehensive decision support system. TCQ

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Yacoob has rounding responsibilities for acute-care patients and maintains an active ambulatory practice. He is also involved in the pediatric residency at Childrens. Yacoob completed his residency program in pediatrics in 1994 and served as chief resident from 1994-1995. He was hired as an attending physician in Childrens' division of general pediatrics in 1995.

Yacoob received his bachelor of science degree in biology from UCLA, where he graduated cum laude in 1985. He received his medical degree from the Albert Einstein College of Medicine in New York in 1991.

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Concurrent to his role at Cerner, Fackler continues to practice in the PICU at The Johns Hopkins Hospital in Baltimore, Md. He also is a part-time associate professor in the department of anesthesiology and critical care medicine within the Johns Hopkins University School of Medicine.

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Fackler received his medical degree from Rush Medical College in Illinois and his bachelor's degree in biology from the University of Illinois.

Among other organizations, Fackler is a member of the American Association of Artificial Intelligence, the American Medical Informatics Association, and the Society for Critical Care Medicine, where he has served as the chairman of the electronic communication committee and represented Cerner on its Coalition for Critical Care Excellence. He is on the board of directors of the Virtual PICU.

Fackler has more than 50 academic publications. He co-authored "Building national electronic medical record systems via the World Wide Web," for the Journal of American Medical Informatics Association. The article was an early description of the use of the Internet for the transport of medical information.

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