

## Information Technology

# Implementing Computerized Provider Order Entry with an Existing Clinical Information System

William M. Barron, M.D., M.M.M.  
R. Lawrence Reed, M.D.  
Sean Forsythe, M.D.  
David Hecht, M.D.  
Julie Glen, R.N.  
Barbara Murphy, Pharm.D.  
Rose Lach, R.N., Ph.D.  
Sue Flores, R.N.  
John Tu, M.D.  
Melanie Concklin, M.S.W., M.B.A.

Computerized provider order entry (CPOE) has been proposed as an important tactic to reduce adverse drug events, however, implementation is difficult and there is significant risk of failure.<sup>1-3</sup> These challenges relate, in part, to the enormous organizational cultural and workflow changes involved in moving from paper-based ordering to computerization,<sup>1-6</sup> as well as the high cost of new systems and product and vendor immaturity.<sup>5</sup> Therefore, it is not surprising that few organizations have implemented CPOE and that there are not many reported successes.<sup>3,7-10</sup>

The extent to which the benefits of CPOE outweigh the accompanying organizational, human, and financial costs remains uncertain.<sup>11</sup> Studies of locally developed, intelligent information systems at technology-intensive academic centers indicate that CPOE can reduce medication errors and adverse drug events.<sup>7,11</sup> However, to what degree the described benefits extend to the commercially available systems used in most health care organizations is less clear. It is also uncertain how much of the benefit of CPOE may be obtained by eliminating handwriting and how much is related to an associated decision support system (DSS).

This article describes the successful implementation of CPOE using a commercially available clinical information system with minimal DSS that had been in place for an extended period.

## Article-at-a-Glance

**Background:** There are numerous barriers to successfully implementing computerized provider order entry (CPOE), and it is not entirely clear to what degree the proposed benefits extend to older, commercially available systems in place at most hospitals.

**Methods:** In 2000, Loyola University Health System leadership chartered a project to implement CPOE for hospitalized patients' medications. The impact of CPOE on workflow was analyzed before implementation. Hardware availability was ensured and input screens were customized for users when possible. A formal education and communication plan was implemented to help reduce resistance to change.

**Results:** Full implementation took 20 months. Transcription-related errors per month decreased by 97% from 72.4 to 2.2 per month. During the pilot period, prescribing-related errors *increased* by 22% from 150 per month to 184 per month—and subsequently decreased to an average of 80 per month, a 47% reduction compared with the baseline error rate. Pharmacist time saved was estimated at 23 hours per month.

**Discussion:** Using an existing CPOE system can provide an affordable, intermediate step on the journey toward implementing a new, state-of-the-art system that provides advanced clinical decision support.

## Methods

### Setting

The current study was performed at a 525-bed teaching hospital on Loyola University Medical Center's (LUMC's) campus. Inpatient care ( $\approx 25,000$  discharges annually) is delivered by 350 full-time faculty physicians of the Loyola University, Chicago, Stritch School of Medicine. More than 560 residents and fellows provide care to the majority of patients and are responsible for writing most physician orders. A small number of patients are cared for directly by internal medicine hospitalists or faculty primary care physicians.

### LUHS' Quality Improvement (QI) Environment and Infrastructure

In 1994, Loyola University Health System (LUHS) made a major, strategic commitment to modern, systemwide QI. Some of the key changes implemented during the past decade are as follows:

- Reorganizing QI structures at both the governance (quality and patient safety committee of the board of directors) and operating levels (quality and safety coordinating council). The goal was to actively engage the board, senior operations management, and clinical leadership to improve quality, clarify accountability, and enhance communication about QI.
- Establishing the center for clinical effectiveness (CCE), a systemwide unit responsible for leading improvements in the quality and value of health care services. The CCE, led by a senior faculty physician and doctorate-level nurse, includes seven staff with QI and data management expertise.

Annually, CCE leadership and senior management develop a list of potential, major, systemwide QI projects to be undertaken during the coming year. This list is discussed and prioritized by the quality and safety coordinating council, which is composed of vice presidents and directors from across LUHS. The project list is then presented to the quality and patient safety committee for final approval and chartering.

In Spring 2000, CPOE for medications, that is, entering medication orders directly into a computer rather than writing them, was proposed as a major, hospitalwide improvement project.<sup>12</sup> The potential benefits and risks, as shown in Table 1 (right), were discussed in detail.

**Table 1. Potential Benefits and Risks of Computerized Provider Order Entry for Medications**

#### Potential Benefits

- Reduction in medication errors leading to improved quality and safety of care
- Savings in pharmacist time
- Fewer calls to residents, nurses, and ward clerks to clarify orders, resulting in fewer delays in patient care
- Decreased costs of therapy through use of preferred medication lists
- Reduced legal liability
- Preparation for subsequent implementation of a new clinic information system with advanced decision support capability
- Increased use of evidence-based practices through creation of diagnosis-specific order sets

#### Potential Negatives and Risks

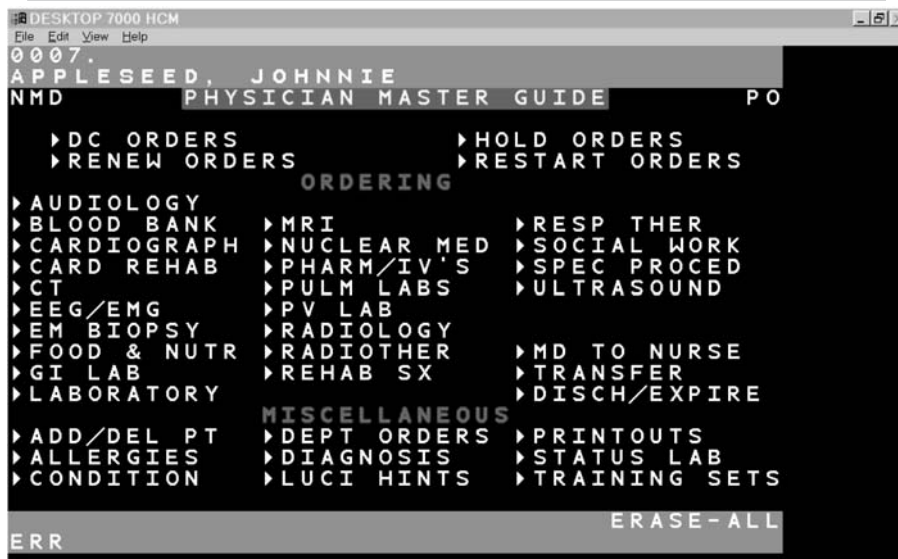
- Increased resident work
- Change in resident, nursing, and ward clerk workflow with slowdown in care processes
- Negative impact on students' ability to learn to write medication orders

Although there was some discussion of financial issues, no formal analysis of return on investment was requested or performed. The primary incentive for the decision was the opportunity to improve patient safety.

The quality and patient safety committee decided to implement CPOE for medications in the inpatient setting. The project was managed by the CCE's executive medical director [W.M.B.], whose performance evaluation depended, in part, on the project's success. Project activity was planned and implemented with an explicit focus on the major cultural and workflow changes that would accompany CPOE initiation.

Two clinically active physicians (a surgeon [R.L.R.] and a pulmonologist [S.F.]) were identified to lead the project, and approximately 25% of their time was purchased from their respective departments. Explicit project deliverables were developed and agreed to by all parties. The project structure included a seven-member steering committee that met biweekly, and a larger committee—composed of representatives of all key stakeholders, including faculty,

## Screen Layout of the Clinical Information System



**Figure 1.** Physicians begin at this screen to order medications individually or through departmental order sets.

residents, administrators, nurses, pharmacists, ward clerks, and information technology (IT) personnel—that met monthly.

### LUHS' IT Infrastructure and Medication Order Workflow

The clinical information system—referred to as LUCI (Loyola University Clinical Information)—which was in use at LUMC at the time of project initiation, was installed in 1986. The nongraphical interface includes a screen that is 40 characters wide and system functionality requires very structured movement from one part of the system to another (Figure 1, above). The application is installed on standard desktop personal computers (PCs) along with library and Internet access and selected other applications. Response time is always less than one second, and system downtime is less than 0.2%.

The clinical information system was designed to support clinical workflow, including order entry, documentation, and results reporting. Two clinical units, the neonatal and burn intensive care units (ICUs), had implemented CPOE for medications several years before the current project began.

At the project's initiation, most medication orders in the hospital were written on blank order sheets

and given to clerical staff (or occasionally nurses) for entry into LUCI. Orders were electronically transmitted to the pharmacy, where the clinical information system generated labels and reports that pharmacists used to dispense and deliver medications. There was no separate, electronic pharmacy system, and pharmacists did not re-enter orders. Pharmacists had access to electronic medication profiles, allergy information, medication administration records, and laboratory information to support evaluation of orders.

When a concern about an order arose, the pharmacist would contact the appropriate provider. Subsequent changes in orders resulted in a written report of a pharmacist intervention. A single clinical pharmacist reviewed each intervention and categorized it as transcribing or prescribing error and assigned a National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP [harm]) category.<sup>13</sup> Errors were defined as follows:

- **Prescribing errors** were defined as those containing incorrect dose, dosage form, route, concentration, rate of administration, or drug selection that was unrelated to handwriting interpretation.

- **Transcription-related errors** were defined as those involving some aspect of the order that occurred as a result of illegible or misinterpreted handwriting.

The majority of existing clinical staff was very familiar with LUCI. Nurses used the system, via standard PC work stations, for documentation, order review, and laboratory results viewing. Resident physicians were already using the system to identify patient location and retrieve laboratory results. Before order entry went live, each resident was offered a nonmandatory two-hour session that included a brief overview, hands-on practice, and a review of common problems. Twelve staff, including nurses, pharmacists, and programmers, supported

the LUCI application and extensively customized the application to meet operational and clinical needs.

### Project Implementation

The steering committee began planning in July 2000. Initial meetings focused on clarifying the project outcomes and time line. The primary outcome measure was the number of transcription-related medication errors intercepted by pharmacists and judged by a single clinical pharmacist to be of moderate or major clinical importance (NCC MERP categories D through I). A secondary outcome was the number of prescribing errors (NCC MERP D-I) intercepted by pharmacists.

Reported adverse medication events were examined but were not considered a major project outcome because of the known significant underreporting of such events.

The literature was reviewed to incorporate lessons learned from the experience of other institutions, especially the University of Virginia Medical Center.<sup>1</sup> In addition, extensive discussions were conducted with the leadership of LUMC's neonatal and burn ICUs.

### Communication Strategy

An extensive, multidimensional education and marketing campaign was implemented that mainly targeted residents, nurses, ward secretaries, and faculty—the stakeholders to be most affected by CPOE implementation. Presentations focused on patient safety as the primary goal. LUHS data on intercepted transcribing and prescribing errors and examples of actual, recent errors intercepted by Loyola pharmacists were presented, which appeared to reduce resistance to change and help physicians understand that their work processes were part of both the problem and the solution. The expected increase in work for residents was acknowledged. The need to further customize LUCI screens and to provide additional hardware was explicitly recognized, and the commitment was made to address these issues when possible. The workflow of nurses and ward clerks was studied in detail and redesigned to reduce the possibility of failure at each step. Extensive time was spent assessing and drafting solutions to hardware (computers and printers) and space issues.

Frequent project team meetings were held to assess progress, identify barriers, and develop solutions, and

**Table 2. Examples of Responses to End Users' Concerns**

- Customization of medication lists and order entry screens. Analysts prebuilt orders in the system, so that they could be entered with a single mouse click, to reflect the medications and dosage regimens that were ordered most frequently by one department's physicians. Customized lists for individual physicians were not permitted.
- Exclusion of chemotherapy orders from the current CPOE implementation. Because of the complexity of writing and entry of chemotherapy orders, most of which involved the use of preprinted order sets, the use of the existing independent checking process, it was determined that the paper-based process was likely to be safer than CPOE.
- Action taken to ensure availability of a sufficient number of computers and printers on clinical units
- Development of a process for telephone, verbal (emergency), and stat orders
- Action taken to ensure that the clerks and nurses understood that they were to help physicians learn the order entry process to improve patient safety
- Development of a backup process to be used when the clinical information system was not operative

the team maintained extensive, ongoing discussions with users. Some of the responses to end users' concerns are presented in Table 2 (above). For example, to speed identification, a common medication list, developed on the basis of pharmacy records, was used to create a screen of the most commonly used medications, making them easier to find than using the alphabetical index for the entire formulary. A sample customized medication list and order entry screen is shown in Figure 2 (page 510).

Regular reports on the project's progress were provided to administrative, physician, pharmacy, and nursing leadership groups. Process control charts listing transcribing and prescribing errors were added to the balanced scorecard of quality measures regularly presented to the board's quality and patient safety committee and the quality and safety coordinating council. Updates were also provided to all staff, physicians, and students in the systemwide newsletter and at the annual systemwide quality and safety fair.



## Screen Customized for Medication Selection on the Neurosurgery Service



**Figure 2.** The screen, customized for the neurosurgery service, reflects the most commonly used medications.

per month, a 47% reduction compared with the baseline error rate (Figure 4, page 512). When expressed as errors per 1,000 medication doses, transcribing errors decreased from 0.34 to 0.01, and prescribing errors decreased from 0.71 to 0.31. The system did not have the capability to count the number of prescriptions reviewed. The number of medication doses dispensed averaged 240,096 per month and did not change significantly from the baseline to the full implementation phase.

Transcribing errors were not completely eliminated because of handwriting errors associated with telephone and verbal orders and noncompliance

### Project Costs

Direct project costs, aside from the time of existing employees who staffed this project, included the following:

- Financial support for time spent by physician leaders (\$66,000)
- Purchase, network cabling, and installation of 155 computers (\$235,000)
- Purchase and cabling for 15 network printers and hardware upgrades for 20 existing printers (\$90,000).

No hand-held, portable, or mobile computers were purchased for this project.

### Results

During the year before CPOE was implemented, transcription-related errors occurred at a mean rate of 72.4 per month and decreased to 56.5 per month during pilot unit implementation. During the 15 months following hospitalwide implementation of CPOE, the transcription error rate decreased by 97% to 2.2 per month (Figure 3, page 511). During the pilot period, prescribing-related errors *increased* by 22% from 150.5 to 184.2 per month. Subsequently, these errors decreased to an average of 80

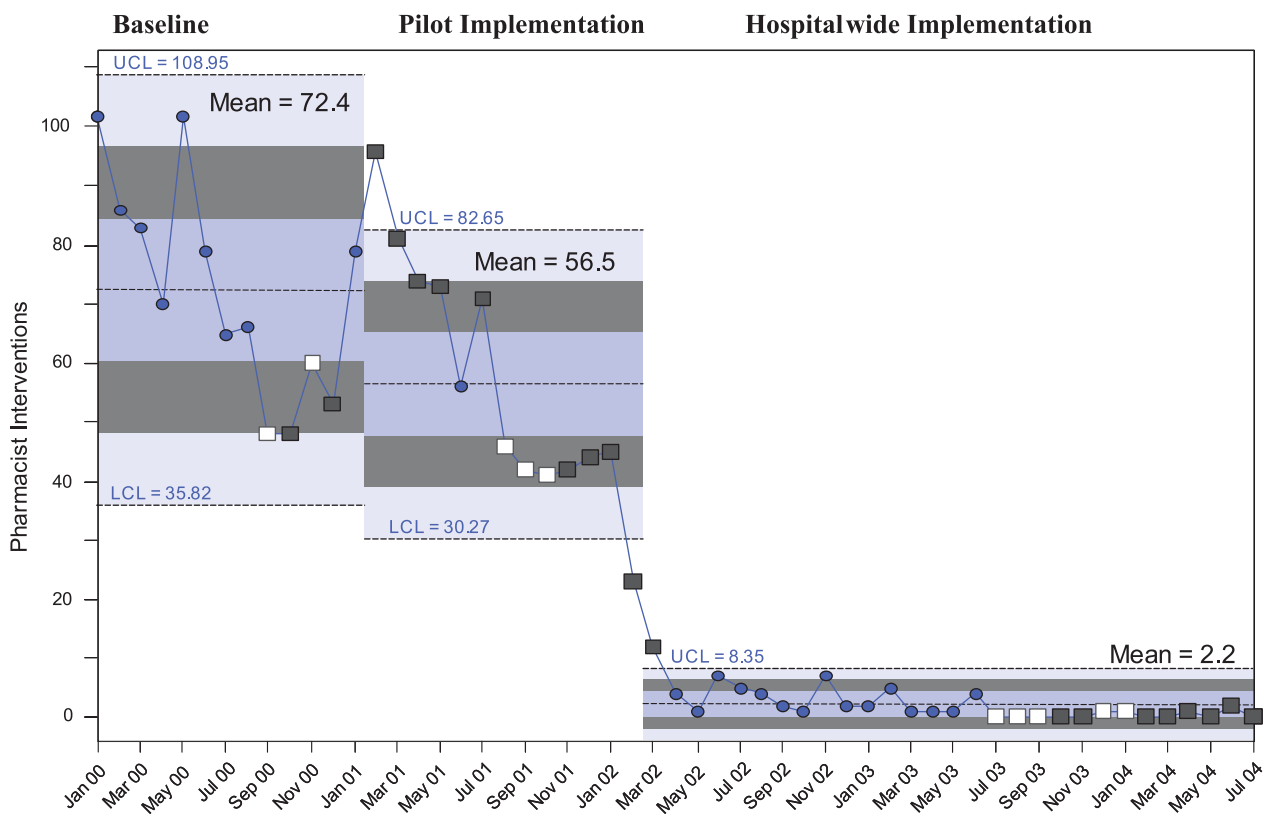
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Transcribing errors were not completely eliminated because of handwriting errors associated with telephone and verbal orders and noncompliance with a policy that stated that medication orders were not to be written by physicians. Discussion with pharmacy leadership indicated that some of the decrease in prescribing-related errors may have been due in part to reduced reporting. This was discussed in turn with pharmacy staff, who were periodically encouraged to document all interventions. CPOE had no impact on the number of reported adverse drug events.

A detailed analysis of the residual errors is presented in Table 3 (page 513). More than one-third of the residual pure prescribing errors, which were primarily due to wrong dose or wrong schedule, related to total parenteral nutrition (TPN) and chemotherapy.

Pharmacy staff noted a significant reduction in the time they spent consulting with nurses and physicians regarding medication orders containing errors. Given pharmacy staff's estimate that it requires approximately 10 minutes to resolve an order-related problem, the saving in pharmacist time is estimated at approximately 23 hours a month. Additional savings in clerical, nursing, and resident physician time were also not quantified. Two years after implementation, informal discussions with resident physicians indicated that they had few

## Transcribing-Related Medication Errors Intercepted by Pharmacists, January 2000–July 2004



**Figure 3.** Before CPOE implementation, a mean of 72.4 handwriting-related errors occurred per month. Following full implementation, the rate decreased by 97% to an average of 2.2 per month.

concerns about LUCI medication order entry and considered it part of their normal work processes.

### Discussion

The success of the current project is discussed below using the framework of nine major considerations for a successful CPOE implementation, as described by Ash and colleagues.<sup>4</sup>

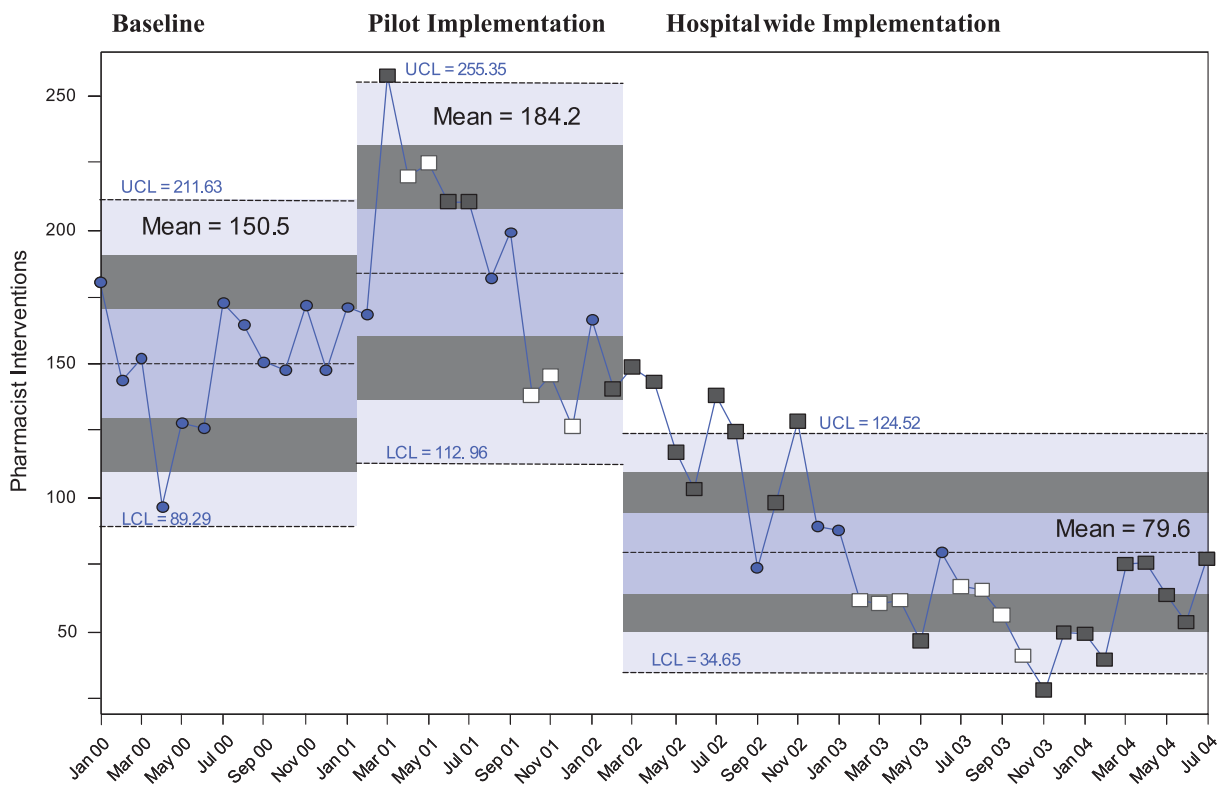
#### Motivation for Implementation

The traditional “business case,” based on financial considerations, has not been established for CPOE. However, a business case for QI projects, such as CPOE, may be organized around additional considerations such as strategy (for example, relationships with payers, branding, product differentiation) and internal organizational considerations (mission, cultural commitment to

quality and safety, impact on staff morale, and retention).<sup>14</sup> Poon et al. suggest that to address the obstacles to implementing CPOE, “hospitals could mitigate the cost barrier by refocusing their priorities on patient safety.”<sup>75(p. 189)</sup> The decision to implement CPOE at LUHS was based entirely on nonfinancial considerations, that is, to improve the safety and quality of care. The availability of data demonstrating the local extent of the patient safety problem was a major factor in creating the incentive to move ahead. Although a formal financial analysis was not requested, organization leaders were aware that there might be a positive financial impact, such as reduced expenditures for treating adverse medication events, avoiding extended length of stay, and the potential for reduced legal liability.<sup>7,11</sup>

The strategic priorities and organizational culture at LUHS in 2000 facilitated the decision to initiate CPOE.

## Prescribing Medication Errors Intercepted by Pharmacists, January 2000–July 2004



**Figure 4.** Before implementation of CPOE, pharmacists identified an average of 150 prescribing errors per month. Initial implementation of CPOE was accompanied by a 22% increase in prescribing errors, however, with hospitalwide implementation the error rate fell to 79 per month, a rate 47% below the baseline level.

Governance and operating structures, charged with the responsibility for overseeing and implementing quality improvement, were already in place. Members of the board's quality and patient safety committee and the quality and safety coordinating council had been actively engaged in similar activities for several years and were poised to identify new projects on a regular basis. In this environment it was relatively straightforward to create a compelling case for implementing CPOE.

### Vision, Leadership, and Personnel

The committees that chartered the CPOE project at LUHS included senior physicians (chief executive officer, senior vice president for clinical affairs) and nurses (chief nurse executive). These persons immediately took ownership of the vision for this project, which was to improve patient safety. They explained in

numerous forums that error reduction was the goal of the project. These senior leaders also understood the magnitude of the project, resource requirements, and the fact that implementation might take an extended period of time.

The project became a major priority of the CCE, and its medical director, who provided project management, was accountable for its success. The center had successfully managed other major initiatives, such as standardizing ambulatory care of patients with asthma and implementing a standard protocol for weaning of adults from mechanical ventilation, using similar change management and QI methodologies. In addition, as stated earlier, two clinically active physicians were engaged to lead the project on a day-to-day basis, with the commitment of financial resources to ensure that they devoted sufficient time to the project.

**Table 3. Analysis of 12 Months (June 2003–June 2004) of Prescribing and Transcribing Errors that Persisted After Full CPOE Implementation\***

	Number (%) of pure prescribing errors	Number (%) of complex prescribing errors <sup>†</sup>	Number (%) of pure transcribing errors
Allergy related	55 (4.6%)	4 (3.3%)	
Ambiguous order (chemotherapy)	5 (0.4%)	3 (2.4%)	
Delayed treatment	3 (0.3%)	1 (0.8%)	
Duplicate additive (TPN)	18 (1.5%)		
Duplicate order	13 (1.1%)	4 (3.3%)	
Duplicate therapy	12 (1%)	1 (0.8%)	
Illegible (chemotherapy)	16 (1.3%)	3 (2.4%)	
Incomplete (TPN and chemotherapy)	174 (14.5%)	19 (15.4%)	
Incomplete other	7 (0.6%)		
Ion imbalance (TPN)	25 (2.1%)		
Overfill (TPN)	53 (4.4%)		
Rate/volume (TPN)	35 (2.9%)		
Unnecessary dose or medication	7 (0.6%)	4 (3.3%)	
Unordered medication (chemotherapy premedication)	29 (2.4%)	2 (1.6%)	
Unstable (mostly TPN)	60 (5%)	2 (1.6%)	
Wrong calculation (chemotherapy)	11 (0.9%)	4 (3.3%)	
Wrong concentration	17 (1.4%)	2 (1.6%)	
Wrong dose	355 (29.7%)	4 (3.3%)	3 (33.3%)
Wrong dose of additive (TPN)	30 (2.5%)	2 (1.6%)	
Wrong drug	28 (2.3%)	6 (4.9%)	1 (11.1%)
Wrong drug additive (TPN)	3 (0.3%)		
Wrong duration of therapy	9 (0.8%)	2 (1.6%)	
Wrong dosage form	59 (4.9%)	10 (8.1%)	
Wrong frequency	81 (6.8%)	2 (1.6%)	
Wrong patient	10 (0.8%)	1 (0.8%)	1 (11.1%)
Wrong rate of infusion	9 (0.8%)	5 (4.1%)	
Wrong route of administration	22 (1.8%)	1 (0.8%)	
Wrong schedule	40 (3.3%)	5 (4.1%)	4 (44.4%)
Wrong volume	4 (0.3%)		
Wrong weight	6 (0.5%)		

\* CPOE, computerized provider order entry; TPN, total parenteral nutrition.

<sup>†</sup> A complex prescribing error is one that involved a prescribing error plus an error in the transcribing, monitoring, administration, or dispensing step.

## Costs

As a major barrier to the adoption of CPOE,<sup>4,5</sup> cost is largely related to the purchase and implementation of a new information system. Because the current project involved the use of an existing clinical information system, costs were limited to time for project staff and physician leadership, as well as the purchase of a modest

amount of new hardware. This approach permitted the organization to focus on change management and work flow without having to deal with numerous technical and organizational issues that usually accompany the implementation of a new information system.

Given the project's success, LUHS leadership began to consider implementing a new, state-of-the-art electronic



health record—with the expenditure of more than \$15 million—that included advanced decision support capabilities (implementation is well under way).

### Integration: Work Flow and Health Care Processes

CPOE has an enormous impact on organizational culture and work processes, and an explicit change management strategy is essential to success.<sup>1</sup> Aarts and colleagues suggest that CPOE implementation should be viewed as a “thoroughly social process in which both technology and practice are transformed.”<sup>2(p. 208)</sup> Similarly, Ash et al. note that the “manner in which CPOE application alters and integrates into existing environments and workflows is critical to its success.”<sup>4(p. 232)</sup> The project’s leadership was keenly aware of these issues, with particular concern about the reaction of resident physicians, whose work processes would be most affected.<sup>1</sup> Resistance decreased substantially when Loyola’s data on the issues associated with transcribing-related medication errors were shared and the opportunity to improve the safety of care was clarified.

Understanding work flow, both before and after CPOE was implemented, was a key part of current project activity. Every key stakeholder group was represented on the project team, and ongoing efforts were made to seek feedback from those most affected by the project. The two physician project leaders made numerous presentations and were readily available to assist with concerns. Every effort was made to modify the system to facilitate work flow (without encouraging undesirable practice), and when such modifications were not possible, stakeholders were promptly informed.

### Value to Users/Decision Support Systems

Decision support capability is a significant value for end users of newer CPOE systems,<sup>4</sup> however, the clinical information system offered minimal decision support. The project’s major value was its potential to improve the safety of patient care. This was demonstrated through a dramatic reduction in transcription-related errors, a previously described benefit of CPOE.<sup>7,11,15,16</sup> Like other organizations, LUHS did not demonstrate a reduction in patient harm (adverse drug events), but it was recognized at the outset that the size and methodology of

the current project were not conducive to address this important outcome.

Residents may have felt that their own personal exposure (for example, shame, legal liability) to the consequences of patient harm would be reduced by order entry, but we did not formally explore this possibility. Nor did we study CPOE’s impact on physician work time; however, we received consistent feedback that the electronic medication order entry took *substantially more time* than the paper process.

### Project Management and Staging of Implementation

As stated, the Loyola CCE, which was responsible for managing CPOE implementation, had both the requisite resources and significant experience with the design and implementation of major, systemwide QI projects. Pilots were conducted to identify missteps that could be addressed before hospitalwide implementation. Communicating the rapid decrease in pharmacist interventions, which represented a readily available metric that stakeholders found credible, provided the positive feedback needed for sustained success.

Using an *existing* clinical information system significantly reduced the scope and complexity of the change effort and set the stage for implementing CPOE using a *new* clinical information system, which is likely to be among the largest, most complex projects that any hospital will undertake. We consider this a major advantage, for it permits a concentrated focus on stakeholder resistance to change and impact of CPOE on work flow.

### Technology

Numerous technological considerations that must be addressed to ensure CPOE’s successful implementation<sup>4</sup> include access, security, customization and standardization of screens, end user’s burden during use, data integrity, interface with other systems, remote access,<sup>4</sup> and, perhaps of greatest value to end users—speed.<sup>16</sup> Fortunately, the clinical information system at LUHS has excellent response times. Yet order entry was a substantial burden because of the structured nature of the screens and the required sequence of inputs. The system permitted a fair amount of customization of medication lists that users found very helpful. Because LUHS employed an existing system, no new or problematic

access, security, and interface issues were faced in the current project.

Another important technology-related barrier to CPOE implementation is product and vendor immaturity.<sup>5</sup> Hospital IT leaders have reported that many current vendor products did not meet their needs and often had serious technological limitations.<sup>5</sup> Use of a clinical information system that is already in place provides one potential solution to these concerns.

### Training and Support

The resources required for training and go-live support of a new clinical information system that delivers CPOE are considerable. We were able to substantially mitigate these needs because all the involved staff were already using other parts of the system. Only the resident physicians, students, and a few faculty required new training specifically on order entry—training that was subsequently incorporated into the routine, annual training that all new incoming students and resident receive. Also, a large group of nurses and ward clerks who were already familiar with the system were available to help physicians learn the order entry process.

### Learning/Evaluation/Improvement

Ongoing assessment and improvement of system functionality should be an important part of all information system implementations.<sup>4</sup> This project's main outcome measure, transcribing errors, is assessed continuously to ensure that the initial improvements are sustained (Figure 3). In addition, the project has been highlighted in numerous venues throughout LUHS. In this manner, the entire health system has learned a key lesson about the value of information technology in improving patient safety. The project was structured to engage users and encourage ongoing communication among physicians, nurses, and clerical staff, and those responsible for managing the system, and suggestions for improvement were numerous.

Despite the realized improvements, a substantial number of prescribing and a small number of transcribing errors persisted. TPN-related orders appear to be related to lack of physician knowledge of the complex TPN formulation process. We have moved

TPN ordering to pharmacists and have seen a major reduction in related errors (data not presented). Whether a CPOE system with advanced decision support will reduce chemotherapy-related errors and the small number of transcription-related errors remains to be investigated.

### Limitations of the Current Approach

The current project depended on the presence of resources and capabilities that may not be present in all organizations, such as the following:

- An existing information system that supports medication ordering
- Information system support personnel with expertise to customize the system to meet end user needs
- Clerical and nursing staff with deep knowledge of the information system who are capable of supporting providers learning how to do order entry
- Employed resident physicians who are responsible for the vast majority of medication order entry.

The absence of one or more of these conditions would create substantial barriers to implementation.

Another potential limitation is that the detection of errors may be biased across time. For example, pharmacists might have reported fewer errors because they assumed that once CPOE was implemented, no errors would occur. We received some feedback that pharmacy staff was increasingly busy and may not have been reporting all medication interventions. In response, results of the project were regularly provided to pharmacists, and the director of the pharmacy sent out reminders about the need for diligent reporting of all medication order interventions. Nonetheless, the magnitude of the reduction in transcribing errors argues that the system changes rather than reporting of errors was primarily responsible for the improvement (decline in errors).

### Summary and Conclusions

CPOE can be successfully implemented in a large teaching hospital using an existing clinical information system, thereby providing an affordable, intermediate step on the journey toward implementation of a new, state-of-the-art system with advanced clinical decision support. **I**

William M. Barron, M.D., M.M.M., formerly Executive Medical Director, Center for Clinical Excellence, is Vice President, Quality and Patient Safety, Loyola University Medical Center, Maywood, Illinois; R. Lawrence Reed, M.D., is Professor of Surgery; Sean Forsythe, M.D., is Assistant Professor of Medicine; David Hecht, M.D., is Professor of Medicine and Chief, Division of Infectious Diseases; Julie Glen, R.N., is Director, Information Systems; Barbara Murphy, Pharm.D., is Quality Improvement Clinical Pharmacist; Rose Lach, R.N., Ph.D., is Administrative Director, Nursing Education and Support; Sue Flores, R.N., is Associate Vice President, Health Care Services; John Tu, M.D., is Director, Electronic Health Record System; and Melanie Concklin, M.S.W., M.B.A., is Quality Improvement Specialist. Please send reprint requests to William M. Barron, [wbarron@lumc.edu](mailto:wbarron@lumc.edu).

## References

1. Massaro T.A.: Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior. *Acad Med* 68:20–25, Jan. 1993.
2. Aarts J., Doorewaard H., Berg M.: Understanding implementation: The case of a computerized physician order entry system in a large Dutch university medical center. *J Am Med Inform Assoc* 11:207–216, May–Jun. 2004.
3. Langberg M.: Challenges to implementing CPOE: A case study of a work in progress at Cedars-Sinai. *Modern Physician* 7:21–22, Feb. 1, 2003.
4. Ash J.S., Stavri P.Z., Kuperman G.J.: A consensus statement on considerations for a successful CPOE implementation. *J Am Med Inform Assoc* 10:229–234, May–Jun. 2003.
5. Poon E.G., et al.: Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. *Health Aff (Millwood)* 23:184–190, Jul.–Aug. 2004.
6. Stablein D., et al.: Understanding hospital readiness for computerized physician order entry. *Jt Comm J Qual Saf* 29:336–344, Jul. 2003.
7. Kaushal R., Shojania K.G., Bates D.W.: Effects of computerized physician order entry and clinical decision support systems on medication safety: A systematic review. *Arch Intern Med* 163:1409–1416, Jun. 23, 2003.
8. Ash J.S., et al.: Computerized physician order entry in U.S. hospitals: Results of a 2002 survey. *J Am Med Inform Assoc* 11:95–99, Mar.–Apr. 2004.
9. The Leapfrog Group for Patient Safety: *With Most Comprehensive Hospital Survey to Date, Consumers Urged to Use Leapfrog Safety and Quality Data to Make Hospital Choices* (press release), Nov. 16, 2004. [http://www.leapfroggroup.org/media/file/Leapfrog-Survey\\_Release-11-16-04.pdf](http://www.leapfroggroup.org/media/file/Leapfrog-Survey_Release-11-16-04.pdf) (last accessed Jun. 30, 2006).
10. Ahmad A., et al.: Key attributes of a successful physician order entry system implementation in a multi-hospital environment. *J Am Med Inform Assoc* 9:16–24, Jan.–Feb. 2002.
11. Kuperman G.J., Gibson R.F.: Computer physician order entry: Benefits, costs, and issues. *Ann Intern Med* 139:31–39, Jul. 1, 2003.
12. Institute of Medicine: *To Err Is Human: Building a Safer Health System*. Washington, D.C.: National Academy Press, 1999.
13. National council focuses on coordinating error reduction efforts. *USP Quality Review* no. 57. Rockville, MD: United States Pharmacopeia, Jan. 1997.
14. Bailit M., Dyer M.B.: Beyond bankable dollars: Establishing a business case for improving health care. Commonwealth Fund Issues Brief, Sep. 2004. [http://www.cmwf.org/publications/publications\\_show.htm?doc\\_id=237489](http://www.cmwf.org/publications/publications_show.htm?doc_id=237489) (last accessed Jun. 30, 2006).
15. King W.J., et al.: The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients. *Pediatrics* 112:506–509, Sep. 2003.
16. Bates D.W., et al.: Ten commandments for effective clinical decision support: Making the practice of evidence-based medicine a reality. *J Am Med Inform Assoc* 10:523–530, Nov.–Dec. 2003.