CHAPTER 1

Computerized Provider Order Entry

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CHAPTER OUTLINE

KEY DEFINITIONS

Alert—a patient- and context-sensitive warning presented to the ordering provider at the time an order is being entered. Used to inform the provider of a clinical concern relevant to the patient and order being placed. Alerts are called "order checks" in some EHR systems.

Clinical Reminder—a context-sensitive electronic prompt to the provider to perform an intervention or procedure, based on the patient's specific clinical data as applied to a set of logical conditions.

Computerized Provider Order Entry—direct entry of medical orders into a healthcare system's EHR by licensed independent practitioners or other staff with specific ordering privileges, and not by clinical or administrative support staff.

Corollary Orders—orders entered as adjuncts to a primary order, e.g., orders for laboratory tests to monitor effects of a medication order, orders for special diets in preparation for a medical procedure.

Downtime—the period of time during which the healthcare facility's computer system is unavailable and electronic order entry is not possible.

e-Iatrogenesis—patient harm caused at least in part by the application of health information technology.[1]

Electronic Health Record (EHR) systems—software programs designed for use by healthcare systems to electronically place, store, and retrieve clinical orders, results, notes, reports, and other information related to the care of patients.

File Architecture—also referred to as the *medication masterfile,* a compilation of interconnected files and records that contain data elements that compose the medication and clinical information presented for use in an EHR system.

Notification—a patient- and context-sensitive prompt to the ordering provider, attending physician, primary provider, or care team to alert them of new information (i.e., abnormal lab result) or tasks in need of completion (i.e., unsigned order or note).

Order Menu—a listing of orders from which clinicians may select individual orders, organized to support a specific purpose, ordering environment, or type of order.

Order Set—a group of medication and procedure orders that can be accessed and ordered from a single source in the EHR, to facilitate entry of multiple orders and standardize ordering for a specific purpose. These are analogous to pre-printed paper order forms.

Quick Order—a pre-configured order in which the components (e.g., medication, dose, route, schedule, amount, number of refills, etc) are specified, allowing for faster order entry and limiting opportunities for entry errors. These are sometimes referred to as order sentences and may be maintained and standardized across an institution or created by individuals as personal quick orders, user preferences or preference lists.

Introduction

The Institute of Medicine's landmark 2000 report, *To Err is Human: Building a Safer Health System,* found that as many as 98,000 people die each year in the United States due to medical errors, and propelled Congress, the Joint Commission on Accreditation of Healthcare Organizations, healthcare professions, and the public towards a renewed commitment to patient safety. A central theme of the report is that bad systems cause most errors, not bad people, and this idea has fostered dramatic advances in clinical systems engineering with safety foremost in design, including "no-blame" error reporting and a call for widespread use of electronic health records.[2] Subsequent IOM reports, *Crossing the Quality Chasm: A New Health System for the 21st Century,* and *Patient Safety: Achieving a New Standard for Care*, emphasized the need for "a national health information infrastructure to provide real-time access to complete patient information and decision-support tools for clinicians and their patients, to capture patient safety information as a by-product of care, and to make it possible to use this information to design safer delivery systems."[3,4] In the Medicare Modernization Act of 2003, Congress mandated the Institute of Medicine to "carry out a comprehensive study of drug safety and quality issues in order to provide a blueprint for system-wide change." This study resulted in the 2007 IOM publication *Preventing Medication Errors: Quality Chasm Series*, in which the Betsy Lehman cyclophosphamide overdose case is used to illustrate how an inferior medication-ordering and delivery system involving minimal double-checks, lack of attending physician oversight, ambiguous protocols, and different dosing expressions in the same order contributed to a tragic patient death; and then how the healthcare system responded, in part by designing a first-class computerized provider order entry interface featuring automatic dose-checking and associated warnings requiring interdisciplinary overrides, extensive point-of-care on-line references, and peer-reviewed templates and protocols.[5] The report further explores sources of medication errors such as gaps in medication knowledge and the lack of timely, easily accessible, and pertinent drug information at the point of ordering; incomplete medication and allergy histories which lack over-the-counter and herbal product information or prescription information from other heath care providers; illegible orders; and unavailability of relevant diagnosis and laboratory results at the point of ordering. CPOE has the potential to dramatically reduce these sources of order errors and significantly improve patient care overall.

What Is Computerized Provider Order Entry?

The term *computerized provider order entry* (CPOE) denotes the direct entry of clinical orders into a healthcare system's electronic health record (EHR) by licensed independent clinicians or others with ordering privileges. The acronym CPOE has different interpretations, including computerized prescription order entry, computerized physician order entry, and computerized provider order entry. We use the latter to emphasize that orders may be entered by physicians, physicians' assistants, nurse practitioners, and other licensed independent practitioners as well as other clinical staff whose scope of practice or protocols grant specific prescribing privileges. A healthcare system can have a comprehensive electronic health record maintained by pharmacists, laboratory and radiology technologists, nurses, dietitians, therapists, medical records specialists, and ward secretaries—all important clinical and administrative staff who are not ordering providers. The full benefits of CPOE accrue only when orders are directly entered by responsible providers and are not placed or scribed by others on the healthcare team on behalf of ordering providers. Orders may include medications, laboratory tests, radiology requests, diets, nursing orders, consultation requests, procedures, equipment, or any other item or service that may have previously been ordered in a paper system.

This chapter will focus primarily on medication orders and corollary orders, such as lab tests, that may be indicated to monitor safe use of a given medication. Most EHR systems use some type of structured order entry format to ensure consistency, completeness, and accuracy of the order. For example, in the Department of Veterans Affairs' Computerized Patient Record System (CPRS), this is referred to as an order dialog box (Figure 1-1). The order

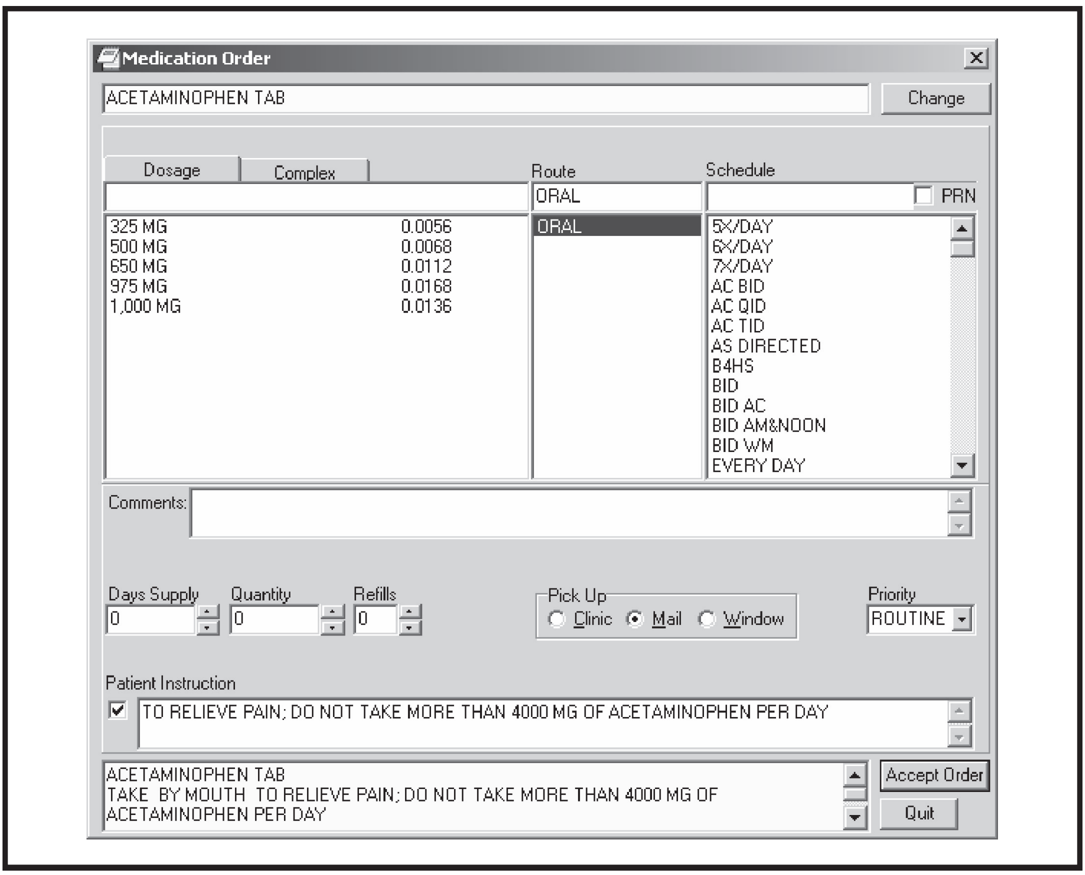


Figure 1-1. Medication order dialog box in VA's CPRS.

dialog includes a pick list for the item to be ordered, as well as the dosage, route of administration, schedule or administration frequency, prescription quantity, refills, and additional instructions for the patient, the nurse administering the medication, or for the pharmacist completing the prescription. A completed dialog for commonly used orders may be saved as a "quick order" or "order sentence" and subsequently retrieved to expedite future entry of the same order. Items frequently ordered together, such as medications and monitoring laboratory tests, may be grouped together into an order set to both facilitate the ordering process as well as enhance patient safety by prompting the provider to order these corollary items. Quick orders and order sets may be grouped together in order menus to facilitate navigation to the correct orders. Once entered, electronically signed, and released by the provider, the order is immediately available to the pharmacist or other receiving service, thereby eliminating transmittal time and misrouting errors as well as the opportunity for errors in transcription or miscommunication.

Many facilities claim to be proponents of CPOE, however, on closer inspection they employ a system whereby pharmacists, nurses, ward secretaries, laboratory personnel and other staff transcribe orders from handwritten paper orders, orders printed from a stand-alone order-writing program, or dictated verbal orders.[6] While insulating clinicians from the possibility of technical problems inherent in the clinician-computer interface, these systems bypass the fundamental benefits of CPOE: the promotion of patient safety and clinical decision support. Progressive EHR systems represent much more than an electronic replacement for the traditional paper medical record: they have come to serve as a comprehensive repository for clinical histories from multiple, diverse healthcare facilities; a compendium of evidence-based order menus and order sets organized to support the latest practice guidelines, responsible resource use, and rapid order entry; a vast library of primary and secondary references organized for rapid access through web links at the point of ordering; and the hub of time-sensitive results and other critical information constantly being updated by clinical ancillary systems such as pharmacy, laboratory, and imaging. The intersection in time at which the busy clinician interfaces with the continually dynamic EHR for the purpose of writing orders represents a unique opportunity to leverage all these capabilities, if well presented, to better inform the clinician of patient-specific factors, guidelines, and the latest research that can improve clinical decision-making for that patient.

Why Is Computerized Provider Order Entry Important?

Impressive patient safety benefits can be achieved with a CPOE system. Illegible hand-written prescriptions are a problem of the past, and CPOE can remind the ordering clinician of a patient's allergy to a specific medication and suggest alternatives or how to manage a reaction. It can alert the clinician of drug-drug interactions, educate on the severity and mechanism of action, and provide advice on managing them. It can check dosages against the patient's physical parameters, laboratory parameters, and previous dosing history and then warn the clinician of potential problems and how to alter a course of therapy. A CPOE system for medications that is integrated with diet orders and diagnoses can alert providers of dangerously incongruent ordering scenarios such as ordering insulin for an NPO patient or teratogenic drugs in a pregnant patient. It can facilitate appropriate monitoring with any potentially risky therapy, such as linking orders for liver function tests with thiazolidinediones and reminding ordering providers to monitor tardive dyskinesia in patients on neuroleptics. It can promote safety at the point of order selection, by detaching "sound-alike" drugs into separate order menus organized by pharmacological class or clinical indication, or by displaying drug names in "tall man" lettering (Figure 1-2). Medication histories, even from multiple healthcare facilities, can be more easily and in some systems automatically maintained, with all of the attendant benefits of medication reconciliation. These are examples of how CPOE can significantly enhance patient safety.

As a result of *To Err is Human*, the Leapfrog Group was convened. This organization is a consortium of purchasers of healthcare plans whose members base their purchases on quality improvement and consumer involvement as evidenced by four "leaps," or recommended practices: computerized provider order entry; evidence-based hospital referral; use of ICU specialists or "intensivists"; and adherence to the Leapfrog Safe Practices Score.[7] Included in the Safe Practices Score is a set of recommended alerts and clinical reminders which healthcare systems are encouraged to employ in their EHR:

1. drug-allergy alert
2. drug-drug interaction alert
3. drug-laboratory result alert (e.g., digoxin level, lithium level, theophylline level, INR, creatinine)
4. drug-monitoring laboratory test alert (e.g., LFTs with statins, TSH with amiodarone, electrolytes with angiotensin converting enzyme inhibitors)
5. drug-diagnosis alert (e.g., pregnancy, G6PD deficiency)

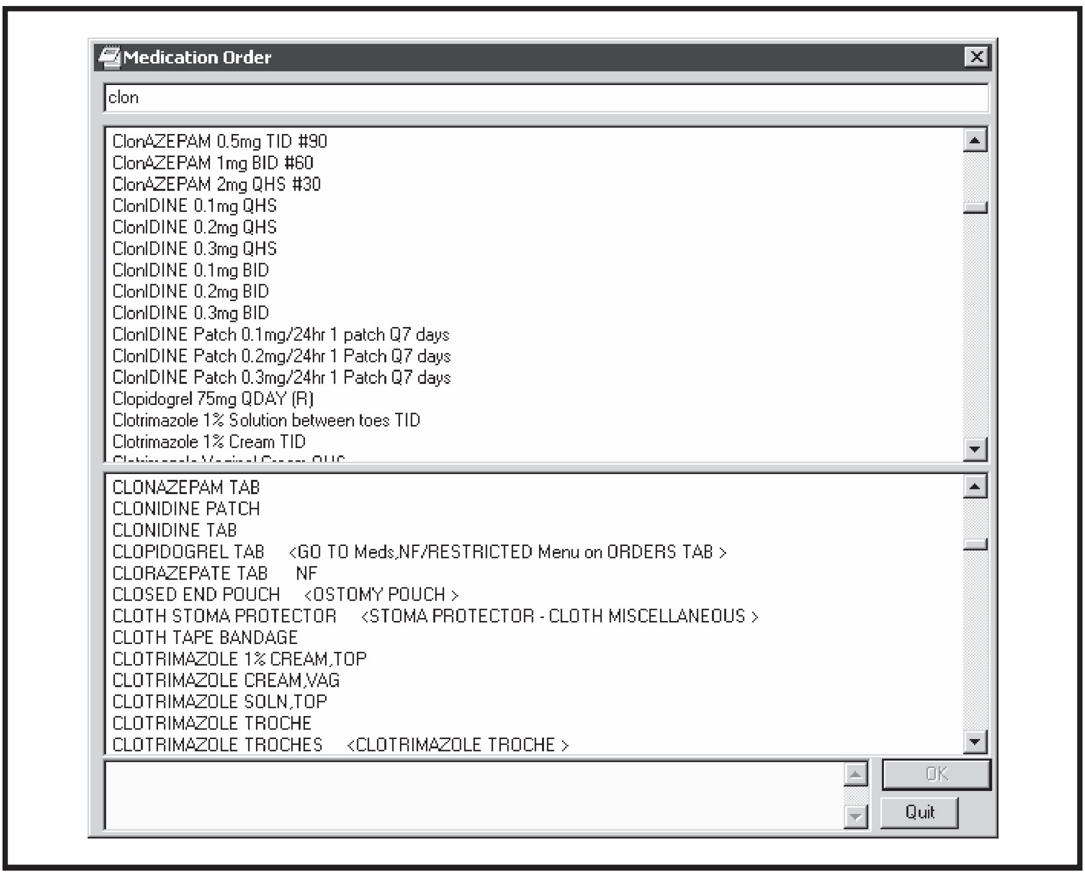


Figure 1-2. An example of "tall man lettering" in VA's CPRS.

6. drug-diet interaction (including NPO, TPN)
7. individual dose checking
8. cumulative dose checking
9. physical incompatibilities (e.g., calcium and ceftriaxone)
10. preventative health clinical reminders

As described previously, in addition to quick orders and order sets, most CPOE programs offer a structured order entry interface or "order dialog" that references an architectural system of interrelated files of order elements, and allows providers to build an order de novo by selecting from various order components. This file architecture is referred to as the *medication masterfile* in other chapters. Careful consideration of how the order dialog interacts with the underlying file architecture can be an important safety aspect of computerized provider order entry, especially for medications. Once a drug is selected, the order dialog should not allow the provider to make ambiguous or dangerously contradictory selections in dosage, routes of administration, or administration frequency, but rather offer appropriate, safe choices to ordering clinicians first, according to the drug selected. For example, it should not be possible to indicate an intravenous route for a medication intended to be administered intramuscularly only. Indications should be easily selected for inclusion in prescription directions for the patient or administering nurse, and should not be merely selectable text that appears in the directions but computable data that can be searched and aggregated for medication use evaluations, billing purposes, and research.

In addition to promoting safe ordering, CPOE can realize other benefits for the healthcare system. Through the use of electronic access and signature codes, electronically-enabled identification cards, and biometric devices utilizing optical or fingerprint scanners, CPOE can verify the identity of the ordering provider and prevent order forgery and other sources of diversion and fraud. It can cross-check the ordering provider's privileges and scope of practice against the orders he or she is attempting to place, and limit the provider to types of orders within his or her clinical specialty, licensure, and privileges. In large health systems or at an agency level, aggregated order data can be analyzed with clinical outcome data, the comparison of such data can lead to clinical practice guideline development, and the result can be fed back into the ordering interfaces to improve patient care for large populations. Studies have shown that CPOE, though initially expensive, can realize significant net savings to healthcare systems over time, due to better drug and staff time utilization, and fewer adverse drug events.[8] The organization and presentation of order menus can help promote hospital-preferred, evidence-based order selection. It can standardize ordering practices, when appropriate, and improve order entry efficiency by grouping orders for common ordering scenarios such as hospital admissions or medical procedures. This is only true, however, if both ordering providers and order receivers are closely involved in the menu design phase, and the health system commits to continuous improvement in its order menu content.[9,10]

Consideration must be given to how and where clinicians place orders, and menus must be designed to support and enhance that action in varying scenarios and by clinicians of different levels of clinical and technical expertise.[9,10] The master order menu architecture might include menus of quick orders sorted by ordering scenario as mentioned above; by ordering location such as the emergency room, women's clinic, or surgical ICU; by order-receiving service (pharmacy, laboratory, radiology, etc.); by chronic and acute diseases; and by listing orderable items alphabetically (Figure

1-3). Menus of order sets and quick orders organized around common and uncommon procedures can assist providers in entering orders quickly in familiar and unfamiliar scenarios according to the health system's accepted guidelines. The menu design could have hospital-approved links to relevant drug information or other resources for clinicians at the point of ordering, references, clinical calculators, patient education print-outs, and community resources. Such links are most efficiently maintained and retrieved via the internet but can reside within the EHR internally if staffing is available to update them. Finally, the component order menus in the master menu infrastructure should ideally be cross-linked, similar to the links in the web pages that form "Wikipedia," so that providers of differing specialization or expertise needing to address unfamiliar co-morbidities from varying ordering locations can quickly navigate to the other menus in the system with minimal clicks.

Key Considerations

Administrative Oversight

An order menu system as described above can promote the use of evidence-based,

Example of Integrated Master Order Menu Architecture

I. Outpatient Order Menus:
  A. Orders by Indication Menu:
    1. Diabetes Order Menu:
      a. Diabetes Medication Menu:
      b. Diabetes Laboratory Menu:
      c. Diabetes Consult Menu:
      d. Diabetes Guidelines and Web Links:
      e. Diabetes Clinic Menu:
      f. Hypertension Clinic Menu:
        i. Antihypertensive Medication Menu:
      g. Lipid Management Clinic Menu:
        i. Antilipidemic Medication Menu:
      h. Ophthalmology Clinic Menu:
        i. Podiatry Clinic Menu:
      j. Neurology Clinic Menu:
        i. Antidepressant Medication Menu:
        ii. Anticonvulsant Medication Menu:
        iii. Analgesic Medication Menu:
    2. Neuropathic Pain Order Menu:
      a. Antidepressant Medication Menu:
      b. Anticonvulsant Medication Menu:
      c. Analgesic Medication Menu:
      d. Diabetes Clinic Order Menu:
      e. Neurology Clinic Menu:
  B. Orders by Clinic Menu:
    1. Diabetes Clinic Order Menu:
    2. Neurology Clinic Order Menu:
    3. Hypertension Clinic Order Menu:
    4. Lipid Management Clinic Order Menu:
    5. Podiatry Clinic Order Menu:
    6. Ophthalmology Clinic Order Menu:
  Medication Orders by Drug Class Menu:
    Diabetes Medication Menu:
    Antihypertensive Medication Menu:
    Antilipidemic Medication Menu:
    Antidepressant Medication Menu:
    Anticonvulsant Medication Menu:
    Analgesic Medication Menu:

Figure 1-3. Example of integrated master order menu architecture.

clinically accepted guidelines that simultaneously educate providers and encourage responsible resource utilization, by making the preferred course of therapy foremost in the design (i.e., the easy default choice), and less preferred therapy available through decision-support algorithms. It is vital to have the support and concurrence of the healthcare system's clinical leadership in the selection of the guidelines and the design of the menus. Some healthcare systems charter a clinical guidelines committee comprised of clinical leaders, researchers, and medical informaticians to establish order menu content based on the latest evidence. For medications, many facilities charge the pharmacy and therapeutics committee with this responsibility, which documents the sponsor, discussion, and date of review of each guideline and menu in its meeting minutes. Ideally the date of the minutes and the menu's sponsors are also displayed on the order menus, making this information available to users. This allows questions or concerns to be directed appropriately. Other facilities convene a successor to the paper "forms" committee, charged with reviewing and sanctioning order sets and templates as the electronic descendants of pre printed paper ordering forms. Ad hoc committees can perform this task, however, the lack of continuity in membership can contribute to a lack of overall vision, a lack of adequate documentation which may be needed for audits, and lead to disruptive changes in menus that can confuse providers.

Build Considerations

An order menu design may involve thousands of quick orders and order sets and hundreds of order menus. For consistency, continuity, and ease of maintenance, the components should be the same, i.e., the same quick order for acetaminophen 650 mg PO Q6H PRN should be a component of the alphabetical drug menu, the non-narcotic analgesic drug class menu, the surgical ward admission order set, and the emergency room medication menu, so that when a change in the quick order is warranted the change can be made at the atomic level and be expressed in multiple menus. Such "object-oriented" design allows a component quick order to be created once but used many times, thereby increasing efficiency and consistency. However, it also significantly increases risk if a component quick order is not built correctly, without full knowledge of the myriad menus where it might occur, or there is a change in the file architecture on which the quick order is based (e.g., a change in the drug, schedule, or route files). This is an example of a *tightly coupled* system, one which responds to changes rapidly and efficiently, but catastrophically if the change is not well-planned and well-executed.[11] It is crucial to successful CPOE that order menus are maintained according to the latest formulary changes and newest clinical practice guidelines, by information systems analysts who possess both the clinical and technical knowledge necessary to safely manage tightly coupled systems.

Understanding Workflow

In addition to programmers, network managers, and technical support, most successful CPOE programs require information systems analysts who are able to act as liaisons between the clinical user community and the technical support staff. They typically are responsible for configuring the EHR and the order entry interface to meet the needs of the clinical users, training the users, and providing support if they have questions. In the Department of Veterans Affairs, these analysts are known as clinical application coordinators (CAC), but this sobriquet is not entirely accurate, since they do much more than coordinate applications. The more knowledgeable these staff members are regarding the clinical policies, procedures, workflow demands, regulatory pressures, organizational culture, and mission of their healthcare system, in addition to the technical aspects of their EHR, the more effective they will be. They understand and can speak in both clinical and technical terms and can serve as translators between clinical users and technical staff. They have first-hand knowledge of the workflow and processes in patient care areas and can both suggest and implement better ways to accomplish clinical tasks through their intimate knowledge of the EHR. Clinical users are often more receptive to an analyst whom they know has been "in the trenches" and can appreciate through personal experience the daily challenges they face. For that reason, staff with prior patient-care experience such as physicians, pharmacists, and nurses are well-suited for this role and must maintain their clinical competency in order to retain their relevance and credibility as they simultaneously acquire new skills, terminology, and contacts in the technological domain.

Professional user support with staff such as CAC's "at the elbow" brought in expressly for that purpose is very helpful during CPOE implementation, but as institutional CPOE experience grows, some support can be shifted to collegial, peer-to-peer support. The healthcare system can plan for that shift by formally recognizing and training front-line "superusers," clinical users whose affinity for technology can assist their peers in adopting the new tools. Likewise, CPOE can be sustained long-term if staff expectations with respect to training and user support are managed from the beginning, through the use of training milestones and accompanying "service level agreements" between the clinical users and the implementation staff. Service level agreements are contractual arrangements between the clinical users and information technology staff that establish the scope of training and user support that meets the needs of clinical users at a level that is sustainable long-term for the information technology staff. Administrative support at the departmental level to reliably manage provider accounts in advance of the providers' arrival will make CPOE function smoothly. Many facilities have linked the need for user support and training, a continual requirement in academic medical centers with high trainee turnover, to succession planning for information technology (IT) professionals. Recognizing the value of first-hand clinical experience to CPOE, they have established a career track whereby "superusers" on the front line can train and support their colleagues while preparing to become information system analysts through formal coursework, then advance to more senior IT positions by undertaking more complex initiatives.

Implementation and Maintenance Strategies

Institutional Leadership

Much has been written regarding the components of a successful CPOE implementation.[6,12] In order for a healthcare system to realize the benefits of computerized provider order entry and not merely replace its paper-based charting system with an electronic version, successful CPOE implementations have found that organizational leadership and an unfaltering commitment throughout the healthcare system to improving patient safety and the quality of care are essential from the beginning. Of all the CPOE implementation and maintenance strategies in the literature and that we can offer herein, enthusiastic and ongoing clinical and administrative support at the highest levels, in terms of funding for equipment and staff, as well as establishing a vision of patient care for all staff, is fundamental to success.

Communication

Communicating changes in CPOE applications, policies, and new initiatives during the implementation phases of CPOE and beyond is critically important, but can be challenging in large organizations with frequent staff turnover, such as academic medical centers. Usually a healthcare system must employ a variety of communication methods to reach the widest possible audience. Electronic and paper newsletters, e-mail bulletins, a regular "CPOE minute" at departmental staff meetings, regular attendance at new staff orientations, participation in morning rounds as well as conducting separate "CPOE rounds" are techniques that have proven to be successful. Posting new information in a designated place on hospital and departmental websites and in team rooms, break rooms, charting rooms, elevators, stairwells, and even staff restrooms is another effective technique. CPOE information of a time-sensitive nature can be posted on websites, broadcast via overhead announcements, sent by high-priority e-mail, delivered by text pagers, and communicated via phone cascades.

Training

Training in basic computing competencies and the healthcare system's EHR of choice should be mandatory but need not be painful. Some facilities initiate their CPOE implementation by encouraging staff to play hospital-sanctioned computer games specifically designed to improve typing, mouse use, and web navigation skills. Short classes with subsequent refresher sessions are better tolerated and generally more effective than a single, marathon training session. New staff should receive their access codes only after they have successfully completed training, whether in the classroom, one-on-one with a trainer, or via the internet. Brief, interactive CPOE training modules available on the web allow incoming staff to prepare in advance of their arrival and existing staff to refresh their knowledge whenever it is convenient.

Infrastructure (Hardware, Software, Configuration)

Adequate hardware in terms of terminal devices, printers, servers, routers, system speed, memory, and reliability are absolutely vital to CPOE, during implementation and afterwards. The implementation and subsequent maintenance plan should accommodate network managers, programmers, technical support staff, help desk personnel, an education plan and staffing, and the aforementioned clinical/technical liaisons who link the clinical, technical, and administrative domains. Planning must include not only the ordering clinicians who will initially interact with the system but also each order-receiving department and the medical records staff, for orders properly placed but not carried out as intended and not adequately documented will quickly derail the implementation effort. Just-in-time training for new staff and the development of a "critical mass" of experienced front-line staff who can provide new staff with on-the-spot help is crucial for making the implementation self-sustaining.

Successful CPOE implementation is a multidisciplinary effort, and the selection of EHR software to fully support this concept should not be overlooked. Ideally, the components of the EHR software should be fully integrated, including the order entry interface, documentation interface, pharmacy interface, as well as adverse reaction tracking, laboratory, dietetics, imaging, nursing, vital signs, surgery, medical procedural, and consult components. This must be done in such a way that it is not necessary for the ordering clinician, pharmacist, laboratory technologist, or other clinical user to log in to a separate program to access different sections of the EHR, and data is fully transferable between components. For example, laboratory results should be as easily retrievable within the pharmacy component as within the order entry interface, and pharmacy data easily retrieved within the dietetics component. The inpatient and outpatient ordering and results review environments must likewise be integrated, to facilitate the continuum of care as it occurs in real life. As mentioned before, healthcare systems are realizing the importance of integrating not only the components of their EHRs, but also the ability to exchange data from their EHRs with other systems' EHRs, to better care for itinerant patients or those who have multiple providers.

Many facilities initially implement computerized provider order entry with electronic replacements for pre-printed paper orders and long, alphabetical lists of preconfigured quick orders organized around the order-filling service: pharmacy, laboratory, dietetics, radiology, and nursing. While these have a place in the overall order menu design, these facilities discovered they were not used by ordering providers to the extent anticipated.[9,10] Multi-layered order menus requiring multiple clicks to reach the desired order and lengthy menus requiring scrolling down the screen were deemed too time-intensive to navigate. Menus of quick orders organized around order-filling services were of limited help to providers needing to quickly place groups of orders intended for different departments, such as medications, laboratory tests, imaging orders, and consults for an emergency procedure. Involving providers in the design and configuration of CPOE tools is critical to success and helps avoid wasted effort.

Clinical/Technical Liaisons

As described previously under "Understanding Workflow," dedicated implementation staff, i.e., those not having direct patient-care responsibilities, who have first-hand knowledge of clinical workplace processes as well as technical aspects of the EHR are critical to implementation efforts. Such personnel ideally should be readily accessible around the clock, by telephone if not in person, during the introductory phases of a CPOE implementation. As the implementation matures, as baseline informatics skills in the healthcare system reaches a critical mass, and CPOE becomes engrained in the workflow, user support can migrate to the aforementioned "superusers." Other forms of user support can involve "help desk" staff available at a standard phone number or through a computerized problem reporting system. The latter can be a simple e-mail message sent to a group of clinical application coordinators, or it can involve sophisticated software programs that triage a problem, alert the most appropriate IT professionals to resolve it, monitor its resolution, and electronically escalate the problem if needed. Similarly, procedures to escalate problems encountered during evening, weekend, and holiday shifts by telephoning on-call IT staff should be developed and widely distributed.

Mature CPOE programs have found it is just as crucial to plan for the return to system availability after a period of downtime as it is to plan for the initial downtime, especially with regard to medication reconciliation.[10] Medications may have been discontinued on paper during the downtime, yet the order may remain active in the computer and prompt for administration until it is discontinued electronically. New medications ordered on paper during the downtime will not appear in the computer for administration upon its return to availability until they are entered, potentially causing errors of omission. Laboratory and radiology results, changes in diet orders and nursing care orders must be entered into the computer as soon as possible, sometimes necessitating overtime or additional staff to enter the data, since the EHR is dynamic and clinical decisions depend on an up-to-date patient record. Policies and procedures for system unavailability and return to normal operations are ideally multi-disciplinary and should accommodate every aspect of the order placing, order receiving, order administration, and order documentation process.

Unexpected Consequences and Unique Challenges

Changes in Workflow Patterns

CPOE can change workflow patterns and communication between members of the patient care team. By placing desktop computers in provider offices, resident team rooms, charting rooms, satellite pharmacies, and even providers' homes, providers, nurses, and pharmacists are physically separated as they interact with the EHR, and attempts to communicate with each other clinically through the EHR cannot match the face-to-face communication that formerly existed when the hard chart in the nursing station was everyone's point of reference.[13,14] However, with the increasing use of wireless mobile computing via tablet PCs and PDAs; medical teleconferencing; and secure, asynchronous provider-to-provider messaging, professional communication is rapidly improving.

e-Iatrogenesis

This term was recently coined in the literature to describe adverse events caused at least in part by the use of health information technology in patient care that would not have happened with non-electronic health delivery systems.[1] For example, an e-iatrogenic event can involve CPOE errors of commission or omission due to an erroneous click due to too many unfiltered choices, erroneous assumptions of how providers interact with an ordering screen, or unexpected changes in order routing.

The concept that computerized provider order entry can solve all of a hospital's ordering problems is obviously wishful thinking. In reality, what often happens is that one problem is resolved as a new issue is created. Examples abound at the Department of Veterans Affairs medical facilities, which have employed CPOE and addressed these issues incrementally for nearly 15 years. With the introduction of CPOE for medication ordering, instantly gone were illegible orders, non-existent hand-written drug names, imaginary routes, and nonsensical schedules. The process by which CPOE notifies the pharmacy department of new orders created a new concern, however. Take for example the following series of orders which, as hand-written orders, would have been faxed together on one sheet to the pharmacy:

1. Mark chart for allergy to ampicillin/sulbactam
2. D/C Unasyn IVPB
3. Solumedrol 60 mg IVPB X1
4. Benadryl 25 mg IV Push X1

In a written system, the combination of the above orders is indicative of an allergic reaction. Pharmacy department policies would likely result in the documentation of an observed reaction, with resulting reports made to the pharmacy and therapeutics committee. To contrast, in an electronic system that distributes orders to various order-filling departments, the pharmacy may only receive orders #3 and #4 (#2 would occur without explicitly notifying the pharmacy). The ordering clinician may have overlooked the importance of entering order #1 (for documentation in the chart). The result is that it is much harder for the pharmacist to take note of this case as indicative of an allergic reaction, and it might be interpreted as a premedication order for a procedure.

CPOE cannot completely remove sources of medication errors. Consider for example the case of two patients with similar names and medical record identifying numbers. In a paper-based system, the patient's ID may be stamped onto an order sheet or progress note form using an addressograph card. The selection of cards available to the prescriber may also be limited to the patients currently admitted to the hospital unit. The transition to CPOE often brings with it the availability of the system's entire patient database, increasing the chances of selecting the incorrect record. Of course, it is possible for these two patients to actually be admitted to the same unit at the same time, and it is similarly possible for the pharmacy system to introduce the same potential for error in the transcription phase of a paper-based system. For this reason, using a second identifier, such as verifying the patient's date of birth, is a recommended step to ensure selection of the correct record.

As described previously, EHRs can incorporate "tightly coupled" systems to increase ordering efficiency; for example, employing the same medication quick order in multiple order menus allows updates to the quick order to be expressed in many locations. However, if the quick order is updated erroneously, the error is also expressed in many locations, multiplying the possibility for adverse patient events. Similarly, some EHRs allow entry of discrete, computable vital sign data concurrently with the entry of text-based electronic progress notes. This increases user efficiency by accomplishing two documentation requirements with one action: the textual progress note and vital sign data. However, if a progress note and embedded vital sign data are entered for the wrong patient, it is critical that both the note and embedded data be retracted, since computable vital sign data, especially patient weight, can be automatically incorporated into weight-based dosing order algorithms elsewhere in the EHR.

How human beings interact with technology to produce results either expected or not expected by the technology designers is the basis of the field of human factors engineering, and has great consequence to CPOE. For example, early versions of the VA's order entry dialog for medications employed for provider convenience use a completion-text matching technology, which allowed clinicians to enter a few characters of a lengthy drug name for which they may not have known the correct spelling and the CPOE dialog would complete the entry. However, the auto-completed entry may not have been the drug intended by the clinician. A clinician could desire to order "Procardia," a calcium-channel blocker, and enter "Procar," not realizing that the closest match to his/her entry is "Procarbazine," an antineoplastic agent, since the "b" in Procarbazine comes before the "d" in Procardia in the drug file. Another example occurred when the Joint Commission for Accreditation of Healthcare Organizations prohibited the abbreviation of "QD." To comply, VA facilities changed their "QD" schedule entries to "Daily," however, ordering clinicians initially persisted in attempting to enter "QD" with their orders. Since "QD" was no longer on file, completion matching retrieved and offered the closest match: "Q12H." In both examples, if the clinician failed to notice the erroneous auto-completed components, the subsequent orders could result in serious harm to the patient. VA resolved these issues by disabling the completion matching feature and requiring the ordering clinician to actively and purposefully select each of the order components. It is of fundamental concern that the design of the CPOE interface not contribute to the commission of errors, but instead guide the clinician to safe choices.

Computer Unavailability (Downtime)

With successful implementation of an EHR and CPOE comes increasing dependence on computer based resources to support clinical care processes. This creates a unique challenge when these resources become unavailable, and strategies and procedures must be in place for both planned and unexpected computer down times which are inevitable even in the best of circumstances. Back-up procedures using paper, local non-networked or alternative computer resources, or a combination of the two must be clearly defined and communicated to all system users in advance. Most large healthcare systems keep files on independent storage media in a physically separate location in the event of a catastrophic outage, and automatically "push" copies of time-sensitive clinical information across the local area network to selected workstation hard drives every 30 minutes to 4 hours to provide a back-up clinical record in the event of lesser outages. Many facilities have found maintaining a "downtime folder" containing paper order forms and instructions for use in each clinical area to be very useful in minimizing disruption when regular computer resources are unavailable. Mature healthcare systems which have completely replaced paper order forms with electronic order menus involving decision-supported algorithms should consider including paper copies of order menus in the downtime kit as well. Having a web-based application that can access back-up read-only data when regular resources are not available has also been a significant asset. Close communication between clinical and technical staff is important in assessing the likely severity and duration of the unplanned downtime leading to the decision of whether and when to go to paper. Communication can occur via overhead loudspeaker, notice on non-EHR computer resources if still operational, telephone cascades, as well as through in-person visits to key clinical areas. Many facilities have adopted a monthly 4–6 hour pre-scheduled, pre-announced downtime to perform preventative maintenance on the hardware, which also affords the opportunity to conduct a computer disaster drill for front-line staff providing patient care. Disruption from planned downtimes can be minimized by sensitivity to clinical processes and close coordination with clinical service leaders. For instance, the time between 7 and 9 a.m. is typically a peak period for medication administration and clinical rounds in inpatient settings and a particularly bad time for planned computer outages. Scheduled planned downtime late in the day on a week end seems to strike the best balance of availability of technical staff and minimizing clinical process disruption. Once computer systems are again available, back entry of orders and documentation created during the down time is generally required to ensure that computerized records are accurate, up to date, and reflect the most current state of patient care. Communication between pharmacy and nursing is especially critical in inpatient settings to ensure that medication administration records are synchronized to avoid duplicate or missed medication doses. Computer downtimes will happen, but careful planning, preparation, and good communication can greatly minimize the impact on both patients and staff.

Information Overload and Desensitization of Ordering Providers

We have previously described how the point in time at which the clinician interfaces with the EHR for the purpose of placing orders represents a "golden" opportunity to leverage an enormous amount of information about the patient at hand and a vast web of clinical decision support tools, references, and research to assist the provider in making better-informed order choices. However, bombardment of uncoordinated and non-prioritized alerts, warning flags, notifications, and reminders at that golden moment quickly leads to alert fatigue and desensitization, effectively negating any benefit these tools might have offered to improving patient safety and decision support. It is important to establish institutional parameters that are above individual departmental agendas to control the application of attention-seeking electronic tools, if the healthcare system wishes to realize the benefits they were intended to provide. Often alternative systems of notification can be devised, such as surveillance reports run at the departmental level, to relieve providers of alerts of a less time-sensitive nature. Likewise, the specificity and usefulness of warnings and reminders must be deemed valuable to the provider if the healthcare system wishes the information to be integrated into the care of the patient, and not discounted and overridden as quickly as possible.[15,16] Cross-sensitivity warnings should have a logical and specific pharmacological basis; drug interaction warnings should include the mechanism of action; and warnings should provide information on severity and management advice with accompanying order menus.

Technology Outpaces Policy

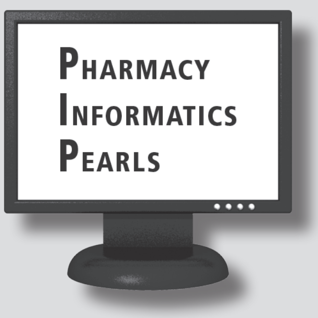
In 2007, the Department of Veterans Affairs began displaying remote drug-allergy, drug-drug interaction, and duplicate drug alerts in all of its 172 healthcare facilities, i.e., the agency's EHR began warning ordering providers of potential order incompatibilities or duplicate therapy based on information on file at distant VA facilities where patients were treated previously. In the future drug-lab result and drug-diagnosis alerts may be added. This capability represents a significant enhancement in patient safety, especially for co-managed and itinerant patients, as well as an advance towards medication reconciliation, the Joint Commission's recent Patient Safety Goal, across the agency. However, this new information created an unanticipated logistical problem for providers. Because clinical privileges are facility-specific, a provider cannot legally, nor does VA's EHR provide the technical means to, discontinue a medication at a remote site even if the patient has been instructed to discontinue it, and therefore cannot support medication reconciliation across the agency. As is often the case where information technology intersects with healthcare policy, the technology and the policy were not initially aligned in their planning, development, or release, yet turned out to be serendipitously synergistic. The details of inter-facility transferring of prescriptions, reconciling remote prescription profile discrepancies, and cross-agency safety initiatives such as anticoagulation management, as well as with non-VA community partners, still need to be elucidated. The implementation of a standard medical nomenclature, including drug names, normalized lab results, etc., that can be shared, interpreted, and calculated equivalently in any EHR system and a basic national EHR architecture to facilitate that data sharing, will be instrumental in moving CPOE to the next phase of improving patient safety and quality patient care.

Future Trends

In the future medication reconciliation and real-time sharing of medical records across diverse healthcare systems employing very different EHRs will be available, with the development of a standardized medical nomenclature and a national health information infrastructure. Inter-facility EHR cross-referencing is especially important for patients who are co-managed by multiple healthcare systems, for itinerant patients such as "snowbirds," and for patients who are transferring their care in large numbers from one healthcare system to another such as military personnel transferring from the Department of Defense to the Department of Veterans Affairs.

Most CPOE systems, even those which are highly integrated, offer different order dialogs for the inpatient and outpatient ordering environments as well as the different order-filling departments (pharmacy, laboratory, imaging, dietetics, nursing, etc.). This is easier to program and makes sense from the standpoint of the order-filling departments, many of which have been using computer programs for their internal workload for years, and onto which CPOE was overlaid. Providers encountering CPOE for the first time, however, are not accustomed to having to search for and select different order dialogs for inpatient and outpatient medications, or for recording the OTC, herbal, and outside medications a patient is taking, then repeat the search for the laboratory order dialog, then for the imaging dialog. A well-designed order menu infrastructure comprised of pre-configured quick orders and order sets for a variety of ordering scenarios alleviates some of the searching and delays inherent in a menu-based system, but to the novice user, this system is personally more time-consuming (though safer and time-saving to the healthcare system overall) than scribbling a series of orders on a paper form. It can, however, contribute to new types of errors, e.g., attempting to order an outpatient medication with the inpatient order dialog or the OTC/herbal/outside med dialog. For safety, consistency, and intuitiveness, order dialogs should be similar in appearance, and to the extent it is reasonable, they should be combined, thereby reducing the need to search for and select the right order dialog. For instance, the inpatient and outpatient medication order dialogs could be combined with those used for ordering medications for use in clinic procedures as well as documenting OTC and herbal products the patient is taking. The combined medication order dialog could feature selectable components (e.g., dosage, schedule, route of administration, prescription quantity, number of refills, and purpose of the order) configured internally in the underlying file architecture to successively offer only safe, logical, and context-sensitive choices for each order component based on the selections of previous components.

An alternative approach to offering multiple order entry dialogs for different types of orders arranged in menus is to design a single "natural language" CPOE interface whereby providers type orders just as they would write them on a paper order, and the dialog references the file of pre-configured order menus, quick orders, and order sets.[17] The dialog retrieves entries by name, and offers the closest matches to the provider for selection and subsequent editing as appropriate. The file entries could be as simple as a quick order for "acetaminophen 650 mg PO Q6H PRN outpatient prescription" or as lengthy and complex as a multi-order "cardiac surgery post-op ICU" order set. File entries should be sanctioned by the healthcare system's clinical management, carefully named and managed with human factors engineering in mind, and continually updated according to approved guidelines. This design may make hunting



COMPUTERIZED PROVIDER ORDER ENTRY

Provider Order Entry

- Direct entry of orders into an electronic health record system by a licensed independent practitioner with ordering privileges.
- Allow provision of time and patient-sensitive warnings and clinical decision support at the point of order placement.

Patient Safety Advantages

- No illegible orders.
- Allergy and adverse drug reaction warnings at the point of ordering.
- Drug-drug, drug-food, drug-lab, and drug-diagnosis interaction warnings.
- "Tallman" lettering.
- Remind or automatically order corollary monitoring e.g., LFTs.
- Individual order and cumulative dose checking
- File architecture can ensure that inappropriate dosage forms, routes, and schedules are not selectable.

Other Advantages

- Verify identity of prescriber and prescriber's ordering privileges.
- Standardize therapy when appropriate according to accepted guidelines.
- Provide opportunity for decision support.
- Enable aggregation of ordering and outcome data, analysis, and creation of new guidelines.
- Facilitate maintenance of medication history from multiple heath care systems.

Order Menus

- Commit time and staffing to providing up-to-date, clinically evidence-based order menus that providers will use.
- Provide administrative oversight via clinical guidelines committee, pharmacy and therapeutics committee, or electronic forms committee.
- Integrate menus supporting different ordering locations, order receiving services, levels of ordering providers, diseases, and orderable items to fully support continuum of care.

Implementation Issues

- Institutional leadership and support is critical.
- Need adequate infrastructure in terms of hardware, software, technical staff, administrative staff.
- Clinical/technical liaisons are crucial for user support, training, and system configuration that optimizes the business of healthcare. Develop an IT career track to ensure connection is maintained.
- Plan for "superusers," peer-to-peer support, service level agreements.
- Develop multi-disciplinary plans for ongoing communication, training, user support, downtime contingencies, security and confidentiality, and EHR content.

Unintended Consequences

- Changes in traditional paper-based communication patterns and workflow can lead to ordering errors.
- Beware of ramifications of "tightly coupled" systems (high efficiency increases scope of errors).
- Be alert to human factors engineering: assumptions and time-savers can lead to ordering errors.
- Plan for scheduled and unscheduled downtime.
- Beware of information overload from unmanaged warnings, reminders, alerts from providers' perspective.
- Foresee how technology can outpace policies, procedures, and practices, and plan for it.

Future Trends

- Medical information sharing across healthcare systems with diverse EHRs via national health information architecture and standardized nomenclature. Adopt and support standards as often as possible.
- Natural language order entry interface obviates need for navigating order menus.

for the correct order entry dialog or navigating order menus in search of the correct quick order or order set obsolete, thereby decreasing order entry time, reducing selection errors, and through careful management of the file entries it could significantly enhance clinical decision support and resource management with minimal impact on the ordering providers.

Conclusion

Throughout this chapter, we have asserted that computerized provider order entry is an essential component of any electronic health record implementation, and the moment at which a provider interacts with the computer to personally place orders represents a golden opportunity to leverage considerable resources towards improving patient safety and applying evidence-based clinical care. Government, regulatory organizations, and patient advocacy groups are calling for "a national health information infrastructure to provide real-time access to complete patient information and decision-support tools for clinicians and their patients, to capture patient safety information as a by-product of care, and to make it possible to use this information to design even safer delivery systems," and CPOE is an integral part.[5] We have offered strategies for implementing and maintaining CPOE, and warned of unexpected consequences. Finally, we offered some suggestions for CPOE interfaces that would make it even more intuitive. When software makes the "right thing to do" also the "easiest way," CPOE will truly have realized its potential.

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