

Consensus Recommendations for Basic Monitoring and Evaluation of In-patient Computer-based Provider Order Entry Systems

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Abstract

Implementing computer-based provider order entry (CPOE) is one of the most difficult organizational change efforts a healthcare system can undertake. To further confound the issue recent reports suggest that in addition to the known difficulties with changes in clinician workflow there are a myriad of unintended adverse consequences that routinely occur. For an organization to have the best chance to manage both these known and unknown difficulties, we believe that a sound CPOE measurement or monitoring system is required. To begin addressing these factors we are developing a set of recommendations for organizations interested in measuring and monitoring their CPOE systems. We identified four main categories of measurements along with several example measures in each that can and should be monitored on a regular basis:

- **Availability/Use** – What CPOE features and functions are available to clinicians?
- **Utilization/Efficiency** – How is the CPOE system being used?
- **Quality or Benefits derived from use of the system** – What effect is the CPOE system having on your organization?
- **e-Iatrogenesis** – What are some indicators of hazard caused by, or resulting from, use or integration of the CPOE system within the larger clinical information system?

We believe that by carefully measuring and monitoring the data that are captured during the routine use of any CPOE system, an organization can begin to develop the knowledge required to help optimize the design and use of its system while simultaneously watching out for potential unintended adverse consequences that may occur.

1. Introduction

Implementing computer-based provider order entry (CPOE) is one of the most difficult organizational change efforts a healthcare system can undertake [1]. To further confound the issue recent reports have suggested that in addition to the known difficulties with changes in clinician workflow there are a myriad of unintended adverse consequences (UACs) that routinely occur [2]. Notwithstanding these known issues, CPOE has been put forth as a solution to many of the problems facing healthcare providers and organizations [3].

Specifically, CPOE facilitates the process through which clinicians create unambiguous orders by improving legibility, reducing the likelihood of missing data, reducing the variability among providers through the provision of default values, and eliminating the need for transcription from one form to another. In addition, by having the clinical decision maker actually entering the order, the computer is able to provide point of care clinical decision support such as drug-drug interaction checking, drug-allergy checking, or suggestions for more appropriate tests via order sets or appropriate medication doses via default values. Finally, the introduction of CPOE greatly facilitates the process of managing many different aspects of the organization including: ensuring that different organizational policies and procedures are followed, identifying specific departments or providers who are practicing in a much different manner than others (e.g., ordering particularly expensive or rare tests or medications), and monitoring various activities within the hospital as part of an overall quality improvement process.

The goal of the metrics described in this paper is to promote the development, implementation, and evaluation of various computer-based provider order entry (CPOE) system features and functions that have the potential to improve the quality of care delivered or reduce the cost of such care. We see these metrics as the first step in a multi-step process that is based on the fact that before one can achieve improvements in the quality of care due to any specific clinical information system feature, the CIS must be available and clinicians must use the system as designed. Therefore, all of these measures focus first on system availability and then on clinician use. Once we have documented that these systems are being used appropriately, then, and only then, can we begin identifying specific clinical quality process measures that are linked as closely as possible to the CPOE or clinical decision support (CDS) feature or function whose use we are measuring.

Recently, we have identified numerous ways in which clinical information systems (CIS) or CPOE use has the potential to result in harm to the patient, called e-iatrogenesis. Therefore, we now believe that it is imperative that we also begin developing measurements to help us monitor CPOE and CIS system activities with the aim of identifying potential problem areas, or hazards, before they result in harm to the patient. The following CPOE metrics were identified based on a review of the literature [see for example:4] and our extensive discussions with the developers and users of many of the leading clinical information systems currently in use. The metrics described below represent only a “first draft” of the complete set of CPOE-related measurements that will ultimately be required to fully monitor and evaluate a particular CPOE implementation. Our goal in presenting them here is to “open the discussion” regarding the continued development and refinement of the complete set of CPOE evaluation metrics.

For an organization to have the best chance to manage both known and unanticipated difficulties, we believe that a sound CPOE measurement or monitoring system is required.

2. Background

In May 2006 a group of clinical informaticists gathered for a 1½ day working session at the Menucha Retreat Center outside Portland, Oregon to discuss various unintended aspects of Computer-based Provider Order Entry (CPOE) [2]. As a consequence of those discussions we began developing a set of recommendations for organizations interested in measuring and monitoring their CPOE systems with an eye toward helping them to a) prevent as many unintended consequences as possible from occurring, b) identify and manage those UACs that may be occurring, and c) develop, implement, and most importantly, monitor and evaluate potential solutions to these challenges. Over the following months we have continued to work with these and additional experts to add to and refine these recommendations.

3. Key Recommendations for Monitoring and Evaluation of Computer-based Provider Order Entry

The first recommendation is to create a national CPOE evaluation and benchmarking center. This center would be responsible for collecting and disseminating CPOE measurements from any health care organization interested in participating. All data will be closely guarded and only de-identified or average data will be available to outside sources.

The second recommendation is to use the following definition of CPOE based on the three most common computer-based ordering methods. Although there may be many different names for the various order entry modes, they all fit into three broad categories based on the relationship between the individual actually placing, or entering, the order into the computer system and the individual authorized to place (or responsible for) the order. These categories are:

- A) The user entering the order is the same as the authorizing provider. This is the prototypical example of CPOE. This includes clinical providers other than physicians depending on what they are authorized to order and may include RNs, advanced practice nurse practitioners (NPs), and physician’s assistants (PAs).

- B) The user entering the order places the order based on communication with the authorizing provider. This mode of communication includes verbal (face-to-face or via telephone) and written methods. These are the orders that CPOE tries to eliminate because of the information loss inherent in the communication mode (poor handwriting, misinterpreted verbal order, erroneous transcription, etc). These orders potentially remove the provider from any system-generated, real-time clinical warnings or alerts (depending on an institution's read back¹ or alert follow-up procedure).
- C) A user other than the authorizing provider enters the order without communicating with the authorizing provider. The authorization is based on a pre-defined clinical or administrative event using a set of standard, pre-defined orders [e.g., standing orders for pneumovax [5]. These orders may be called standing or protocol orders depending on the institution. Additionally, they may or may not require co-signing by an authorizing provider.

The proportion of orders placed using CPOE is easy given just categories A and B: $\%CPOE = A/(A+B)$. The orders in category C present a challenge to our definition. However, that challenge is mitigated when we consider the overall goal of defining CPOE. The reason to measure an institution's percentage of CPOE is primarily to benchmark their rate of success in reducing the number of orders transmitted with the potential of information loss (Group B). From a patient safety standpoint as well as the homogeneity of clinician workflow, a high percentage of CPOE is seen as good. Clearly, orders placed using CPOE are safer than written or verbal orders due to removal of the transcription step and elimination of the legibility problems. Given this goal, where do standing, or protocol, orders (Group C) lie?

For the sake of this discussion standing, or protocol, orders are defined as sets of orders built into the CPOE application, which are carried out for any patient, that meet a pre-defined set of criteria. These plans of care are discussed and approved by the medical staff and become hospital policy. They are designed to facilitate patient care in cases where contacting the authorizing practitioner would delay care (emergency protocols for shortness of breath or chest pain, for example). They can also be used in cases where routine events occur and the same procedures are always followed (transfer of a newborn to the nursery, for example).

Standing orders and protocol orders actually match the main reasons for using CPOE as outlined above. First, they eliminate ambiguous orders by utilizing pre-defined order sets for each condition or event. Essentially the communication has taken place up front in the form of the medical staff policy and the authorizing providers have already signed off on the treatment plan. Secondly, these situations should, by design, require minimal clinical decision support processing. Finally, since the order sets are pre-defined and the orders have already been entered into the system and only require selection from a menu or list, the organization benefits by being able to measure and monitor their use in the quality improvement process. Given this, we consider standing or protocol orders as a "good thing", since they improve the timing of care, reduce the variation of clinical practice and eliminate ambiguous orders.

As such, we propose the following definition for CPOE:

$\% CPOE$ equals all CPOE orders plus all protocol, or standing, orders divided by all orders placed.

OR

$\% CPOE = A+C/(A+B+C)$

4. Proposed Measurement Categories along with Sample Measures

The group of experts identified four main categories of measurements, which parallel the "Structure, Process, Outcome" measurements identified by Donebidian [6] in his effort to monitor and assess healthcare quality, along with several example measures. For example, rather than Structure, we refer to CPOE system availability. Briefly, robust CPOE availability is essential before any of the previously identified benefits can occur. Similarly, installing CPOE and making it available will have little or no impact on an organization unless it is used (the process) by the clinicians. Only after we have ensured that the system is available and used can we begin to measure the impact or outcomes associated with the system. Finally, we

¹ Joint Commission on Accreditation for Health Organizations (JCAHO) recommends that the health care organization require a verification "read back" of all verbal and telephone orders (not limited to medication orders) by the person taking the order. [Paine SJ & Benator SG. JCAHO Initiative Seeks to Improve Patient Safety. Drug Benefit Trends 15(1):23-24, 2003.]

have added an additional outcome-related category, namely monitoring for potential e-Iatrogenic events. We believe that all of the following measures can and should be monitored on a regular basis:

- **Availability / Use (Structure)** – What CPOE features and functions are available to clinicians?
Summary: CIS must be working; system must be available and fast; there must be enough terminals; CPOE application must be available on each unit.
 - Percentage of system uptime (or downtime) (measured to the minute) of the CPOE application (should include both planned and unplanned downtime of all aspects of the system that affect users, e.g., database, network, applications, application interfaces, workstations, etc.). The system uptime percentage is the single most important measure of system availability. Failure to include the “planned” downtime in this measure makes the information technology infrastructure appear more reliable, but from the frontline clinician’s, or patient’s, viewpoint it represents a significant gap. A particular difficult concept to incorporate in this measure is how to take into account a “partial downtime” in which an isolated computer, an entire floor of a hospital’s system goes down, or perhaps just a portion of the clinical data in the system becomes unavailable. To gain a better understanding of the true impact of system downtime on users, some organizations calculate the total number of clinician-hours the system is not available. Using this form of the calculation a hospital that averages 100 clinicians on duty 24 hours/day that reports a system uptime of 99.5% would experience 84 clinician-hours of downtime each WEEK! Of particular note, is the fact that as more clinicians begin using the system, the number of clinician-hours of downtime will increase unless the percentage of uptime concomitantly increases.
 - Mean response time of a CPOE system as measured (to the tenth of a second) from the users’ perspective (includes delays resulting from database, network, application, workstation). This could be measured by creating a simple query for a “test patient’s” most recent laboratory test results. This query could then be programmed to automatically run every minute from one or more terminals in a clinical setting. The time the query was activated and the time the result was available should be logged to a file. Using these data, one can plot the system response time versus time of day, 24 hours a day, 7 days a week. If there is no “result available” time in the log file for any query, then one should assume that the system is “down” for that minute. Again, while the information technology department may argue over who is responsible for the poor system response time, the clinicians are only interested in finding out how fast the system responds.
 - Ratio of workstations, handheld devices, mobile computers, and printers to staffed beds. These data should be sorted by ICU and Acute care. Comparison of this ratio across organizations can help an organization understand whether it has enough hardware to satisfy clinical needs. An additional factor that must be included in this measure is that all the additional clinical functions are “live” on any particular unit (e.g., if nurses are using the system for clinical documentation in addition to the CPOE function, then significantly more system access points will be required).
 - Percentage of all clinical in-patient units (e.g., ICUs, acute care nursing units) with CPOE live as determined by whether a process exists for clinicians to enter their orders for patients on that unit and have them carried out. This measure is particularly important during the “roll-out” phase of any CPOE project. Once an organization reaches 100% CPOE availability, then the measure can be retired. The total time required to go from first CPOE pilot site until 100% CPOE availability should be recorded and reported along with all the other measures to the national CPOE benchmarking center so that future CPOE implementers can gain some insight into the mean time to full CPOE availability for similar organizations using CPOE products from the same vendor.
- **Utilization / Efficiency (Process)** – How is the CPOE system being used and who is using it?
Summary: Users must first login to the system; the providers must enter the orders; they should use order sets when available; they should take the default values, when available, at least 60% of the time.
 - Percentage of active (responsible for some aspect of patient care) clinicians (MDs, RNs, PAs, etc.) who login to some portion of the CIS infrastructure on a weekly basis. This measure helps the organization learn how far they have to go, before they can expect to see high percentages of CPOE. This is a good measure during the initial CPOE-rollout period. Once the system is up and running on all clinical units then this measure can be retired.
 - The percentage of all orders (i.e., medications, laboratory, radiology, etc.) entered by physicians, or others responsible for making clinical decisions (i.e., MD, PA, or Nurse practitioner). As described in detail in the background section of this paper, this is the key measure for any CPOE system, and what we call %CPOE.
 - Total number and percentage of order sets that are actually used in a 12-month time period. This helps the clinical decision support system developers understand whether the clinical content they have developed is

being used as expected. While the 12-month period may seem long, it helps one take into account specific order sets which may be more heavily used during certain seasons of the year.

- Percentage of all orders whose default values are modified by the ordering provider.: # of times each item was ordered and default was changed / total # of times each item was ordered – sum over all ordered items. A high change rate (>25%) indicates that the default values are not appropriate.
- **Quality or Benefits derived from use of the system (Outcome)** – What effect is the CPOE system having on your organization?
Summary: If alerts are firing too much it can indicate either a quality problem with the care being delivered or that the alerts are too sensitive or that they are not specific enough; if patients have orders for medications that interact, have too high or too low of a dose, or to which the patient is allergic, it could signal that either you have a quality problem or that your CDS is not working.
 - Percentage of all (and total number of each) clinical alert(s) that actually fire on a weekly, monthly or quarterly basis. This measure helps system designers figure out if the sensitivity is too high or the specificity is too low for their alerts. It can also help identify specific alerts that account for a large percentage of the alert burden on clinicians.
 - Percentage of all orders requiring co-signing that are not co-signed within 24 hours. Failure to co-sign orders in a timely manner is an indication of poor compliance with accepted hospital policy.
 - Percentage of all active in-patients with orders for medications for which the specified dose exceeds recommended dose ranges. A high percentage of patients with doses that are too high or too low indicates a potential quality of care issue.
 - Percentage of all active in-patients with orders for medications to which an allergy has been documented or allergy to other drug in same category exists [7]. A high percentage indicates that either the allergy information on your patients is not believed by clinicians or that clinicians are ignoring the warnings.
 - Percentage of all active in-patients with orders for medications that pose a known dangerous interaction (i.e., a black box warning as defined by the Food and Drug Administration (FDA)) when administered via the same route concurrently [7]. A high percentage here indicates that your efforts to improve the quality of care are not working as expected.
- **e-Iatrogenesis (Outcome)** – Indicators of hazards caused by or resulting from use of the CPOE system or other aspects of the clinical information system.
Summary: Potential CPOE-related hazards can result from many different system design decisions or clinician usage patterns including: failure to log-off appropriately; overuse of the copy and paste function; a high rate of over-riding alerts; problems with system-to-system interfaces; and entering orders using freetext rather than coded terms.
 - Record of the ratio of user-initiated system logouts to total system logouts (includes automatic timeouts or aborted sessions). This metric helps the organization learn whether clinicians are properly securing the workstations when they are unattended. Failure to logoff represents both a patient confidentiality problem as well as the potential for users “poaching” or illegally using the system with another user’s login credentials.
 - Percentage of each progress note that is copied from the previous progress note (Plagiarism). A high percentage indicates that clinicians may be over utilizing a system feature that leads to redundant and difficult to read clinical progress notes.
 - Percentage of (pop-up) alerts ignored/overridden. A high percentage indicates a problem with the clinical decision support system or with the clinicians’ belief in the rules that have been implemented. Either way something must be fixed because over alerting can affect clinicians’ ability to concentrate on their work.
 - Percentage of daily system interface efficiency (i.e., number of successful transmissions / total number of transmissions attempted) for the top 5 (by volume) clinical interfaces (e.g., pharmacy, laboratory, ADT, radiology, nutrition). This percentage should be very close to 100% and ALL system-to-system interface problems should be quickly investigated and fixed.
 - The percentage of all orders that are entered as “miscellaneous” or all freetext should be monitored and reviewed periodically (quarterly, semi-annual, annual). Freetext entry of orders eliminates the possibility that the computer can provide any clinical decision support to clinicians.

5. Summary

A CPOE system generates an enormous amount of data. We believe that by carefully measuring and monitoring the data that are captured during the routine use of the CPOE system, an organization can gather the data required to help it optimize the design and use of its system while simultaneously watching out for potential unintended adverse consequences that may occur.

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