AHA Guide to Computerized Physician Order-Entry Systems

American Hospital Association

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Preface

The American Hospital Association (AHA) publishes this white paper for the purpose of sharing with health care decision-makers what has been reported about computerized physician order-entry systems. Specific vendors and vendor systems were not evaluated and are not profiled in this report. While every attempt has been made to make this conceptual overview as comprehensive and useful as possible, the AHA does not make any warranties as to the completeness of this information. The *Guide* is intended only as a primer on the subject. It should be supplemented with other research and expert advice before deciding to purchase a system of the type described herein. **The white paper is meant to serve as an information resource, and is not intended to represent the organizational position of the AHA relative to these systems.** AHA makes no representations or warranties of any nature whatsoever about such systems, including any regarding the utility, accuracy, or fitness for a particular purpose.

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Executive Summary

Hospitals and health systems are turning increasingly to information technology to help address the problem of medication error, support physicians in the practice of evidence-based care, and control costs. One such technology is computerized physician order entry (POE), often linked with a knowledge base and rules-based logic to assist the physician with clinical decisions. Benefits of such systems are well described in the medical literature, at least in terms of improving physicians' ordering practices.

Studies demonstrating improvements in patient outcome are limited, as are studies of the costs and success factors related to implementation. Potential benefits include:
- ♦ improved patient safety
- ♦ increased timeliness of care
- ♦ better use of current medical knowledge to enhance appropriateness of care
- ♦ better coordination of care
- ♦ fewer missed opportunities for preventive care
- ♦ ability to aggregate data for epidemiologic analysis
- ♦ control of costs

The decision to invest in a POE system hinges on weighing these potential benefits, the lack of formal evaluation of most commercial products, financial considerations and institutional characteristics that may be associated with successful implementation. While such systems have the potential to deliver great benefit, they should not be seen as a panacea for patient safety concerns; indeed, any new system also carries with it the capability of introducing new sources of error. A decision algorithm is presented in Figure 1.

Important features to look for in a system are described, particularly those that relate to user-friendliness, system structure, compliance with data standards, and vendor qualities. Successful implementation also depends heavily on good organizational leadership; planning; customization to local work patterns; end-user involvement particularly of the medical staff; timely technical support, and clinical oversight.

Compared with paper systems, POE systems often require additional time for entry of orders and tend to force resolution of long-ignored differences between professional practices and institutional policies. On balance, however, they hold the potential to increase the productivity of health professionals, allowing for more time with patients to address unique aspects of their care. Additional information resources are provided for the interested reader.

This white paper seeks to inform the healthcare decision-maker by:
- ♦ Defining computerized physician order-entry systems.
- ♦ Providing background on the context for such decisions.
- ♦ Offering strategic considerations before investment in such a system.
- ♦ Identifying features to assess before purchasing a commercial system.

- Outlining key success factors in the implementation of such systems.
- Clarifying for health professionals the importance and impact of such systems.
- Providing a glossary of terms and extensive listing of references.

This white paper is meant to serve as an information resource, and is not intended to represent the organizational position of the AHA relative to these systems.

Chapter 1. Introduction to Computerized Physician Order Entry

A recent survey showed that only about one third of U.S. hospitals have a computerized physician order-entry (POE) system completely or partially available, and of those that do, over half reported that fewer than 10 percent of orders are entered this way (Ash JS, 1998). Even these statistics may be overly generous, as it is likely that many of the systems referred to by respondents, although capable of accepting physician order entry, were not designed for that; rather, they were designed and installed with the primary intent being for clerk or nurse order entry (McDonald CJ, 2000). Although innovators began designing and using POE systems over 20 years ago, this technology has been slow to catch on, and most early adopters of this technology began using POE within the last 10 years.

It is likely that in the next decade we will see more widespread use as various factors converge to make this happen. Those factors include an exponential growth in medical information resulting from biomedical research, pressure from purchasers and accreditation organizations to measure and improve quality, advances in information and wireless technology accompanied by drops in the price of that technology, increases in computer literacy among healthcare professionals, and pressures from managed care to control costs and provide better documentation of care decisions (Sittig DF, 1994). Increased professional and public awareness of medication errors has also added impetus to the re-examination of such systems and how they might fit with other forms of automation, e.g., pharmacy systems and automated medication dispensing systems for nurses. The Leapfrog Group, a coalition of purchasers of healthcare from employer organizations and Fortune 500 companies, for example, is developing purchasing principles designed to encourage large employers to selectively offer health plans that require provider hospitals to have in place a computerized physician order-entry system (Smetzer J, 2000).

The American Hospital Association (AHA) has prepared this *Guide* to help healthcare executives and medical leadership make decisions about investing in, purchasing, and implementing such systems for their organizations. It is meant to serve as an information resource, and is not intended to represent the organizational position of the AHA relative to these systems.

What is Computerized Physician Order Entry?

POE systems come in many different configurations, making it difficult to compare experiences from one setting to another. Strictly speaking, POE is simply a system for direct entry of one or more types of medical orders by a physician into a system that transmits those orders electronically to the appropriate department. Some are now referring to these systems as "*Prescriber* Order Entry" because physician's assistants, nurse practitioners, dentists, podiatrists, and pharmacists are all prescribing in hospitals. At a minimum, such systems enhance the legibility of orders and have the potential for more rapid and efficient execution of orders. Many other potential enhancements to such a basic system exist that may be optionally added, including such features as:

- *Specific Designs for Setting*: inpatient care only, ambulatory care only, or both.
- *Specific Designs for Function*: may be function-specific (e.g. laboratory or pharmacy only) or integrate many different clinical functions and possibly administrative functions (e.g. billing) to create a comprehensive computer-based patient record (IOM 1997).
- *Specific Designs for Provider*: may be physician-specific or accommodate data entry by non-physician caregivers e.g. nurses, physician's assistants, medical students.
- *Off-site order-entry*, including from office or home.
- Physician-selectable *standardized orders (single) or order sets* (logical groupings of orders to address a specific condition or situation) from system menu.
- Automatic implementation of facility-approved *standing orders* triggered by specific patient situation, e.g. pre- or post-procedure.
- *Formulary management*: menu-driven medication orders may limit choices to those in the appropriate formulary.
- *Data input device options* that take advantage of technologies other than the workstation keyboard. These include:
  - mouse pointing device
  - light pen pointing device
  - touchscreen monitor
  - voice recognition software
  - hardwired interface with personal data assistants (PDAs) to provide physicians with a handheld means of entering orders
  - use of wireless or infrared technologies to link PDAs to the facility's information system
- *Passive feedback* that simply presents organized clinical data about a patient to the caregiver – information that is not processed, e.g.:
  - electronic access to the most recent patient *test results* and/or temporal trend data
  - information on *charges* for specific orders
  - online text-based *reference material* (e.g. *Physician's Desk Reference* and facility-specific protocols/critical pathways)
  - online *notes* (procedure, admission, discharge)
- *Active feedback* -- Arguably the biggest advantage of POE is the capability to add real-time, active *clinical decision support*. This feature is designed to directly aid the physician in the clinical decision-making process by generating patient-specific assessments or recommendations through the integration of known characteristics of individual patients with computerized knowledge bases and pre-programmed clinical rules (Austin CJ, 1998):
  - Alerts and reminders are generated to alert the caregiver when a value is out of normal range or an intervention is overdue. Alert systems may operate in real time, when the provider is online making the order, or in delayed mode (if the caregiver is not online notice is delayed until he or she is reached), or both.
  - Critiquing systems go a step further and automatically provide diagnostic or therapeutic suggestions at the time that an order is written, based on expert

clinical rules incorporated into the software program. Patient safety is enhanced, for example, by automated medication order checking (e.g., dose range checking, drug-drug interaction, and drug allergy checking).

Clinical decision support generally does not refer to artificial intelligence systems – software that couples pattern recognition and reasoning with known medical knowledge in an attempt to replicate the actual decision-making of an expert physician. The focus of clinical decision support is on improving the decision quality of the average clinician with the average patient, rather than assisting the expert in tackling the difficult diagnosis of the exceptional patient (Eclipsys, 1999).

What Other Forms of Automation Help Reduce Medication Error?

The medication use cycle includes prescribing, dispensing, administering, and monitoring. POE systems are capable of reducing errors at all stages in the medication use process. Other systems also can potentially enhance safety at various stages in the process (Bates DW, 2000). Pharmacy information systems, for example, can check for inappropriate dose range, drug-drug interaction, and drug allergy. Some pharmacy systems even employ automated or manual checks against patient laboratory values, where appropriate. Automated medication dispensing systems for nurses have the potential both to reduce dispensing errors and add new sources of error. POE systems with clinical decision support are uniquely qualified to prevent prescription errors due to lack of available information on drug or patient, and transcription errors due to the misreading of the name or dose of a handwritten drug. Even in these situations, however, some pharmacy information systems may be able to provide a level of interception (McDonald CJ, 2000).

Chapter 2. Clinical Benefits and Impacts of Computerized Order Entry

Why the Interest in Computerized Physician Order Entry?

POE systems offer a number of advantages:

- Orders are legible
- Some transcription is eliminated (complete elimination would require that the system supplant the need for nurse transcription, possibly through an electronic medication administration record)
- The writer can be identified
- Orders can be rapidly routed to their destinations, thus helping to address errors due to poor handwriting, making it easier to clarify questionable orders, and avoiding delays in order processing
- Most importantly, the system can check orders and provide clinical decision support in real time (Bates DW, 1996; Bates DW, 1999a)

POE systems, especially when coupled with clinical decision support, hold the potential to help physicians reduce errors, eliminate unnecessary delays, deal with a rapidly expanding body of medical knowledge, increase the appropriateness of medical interventions, reduce fragmentation of care, assure that preventive services are not overlooked, control costs, and allow care managers to see the bigger picture. Meta-analysis of recent published studies has convincingly shown that these systems with clinical decision support are able to improve physician performance in both the inpatient and outpatient settings (McDonald CJ, 1980; Johnston ME, 1994; Balas EA, 1996; Hunt DL, 1998).

<u>Improving Patient Safety</u>

POE systems have been shown in multiple studies to reduce medical errors. In one study, a chart review of a cohort of 3,138 medical patients identified 133 adverse drug events (ADEs) that were then assessed for preventability using different levels of information systems. Five percent were judged preventable with a system that would simply present results for all diagnostic tests, all current medications, and demographic information (passive clinical decision support). Thirteen percent were judged preventable using a system where all orders would be entered online by physicians, and 23 percent were judged preventable by systems that would present additional data such as automated problem lists (Bates DW, 1994a).

Another study focused on medication errors as a cause of ADEs. Medication errors were found at a rate of 5.3 errors per 100 orders for a mean of 1.4 per admission. Of these errors, 53 percent involved at least one missing dose of a medication, 15 percent involved other dose errors, 8 percent frequency errors, and 5 percent route errors. Of the 25 identified ADEs, 20 percent were associated with medication errors and all of these were judged preventable. POE with clinical decision support could have prevented 84 percent of non-missing dose medication errors, 86 percent of potential ADEs, and 60 percent of preventable ADEs. The authors conclude that medication errors are common but relatively few result in ADEs. Those that do, however, are preventable (Bates DW, 1995a). Further study showed that preventable ADEs occurred most often at the stages of ordering (56 percent) and administration (34 percent), with transcription (6 percent) and dispensing errors (4 percent) being less common. Errors were more likely to be intercepted if the error occurred earlier in the process (Bates DW, 1995b). These data suggest that POE with clinical decision support has the potential to significantly reduce the number of serious medication errors (Bates DW, 1999b).

This is further supported by a systems analysis of ADEs to identify underlying causes of the errors leading to the ADEs. The most common systems failure was in the dissemination of drug knowledge, particularly to physicians, accounting for 29 percent of 334 errors. Another 18 percent of errors were traced to inadequate availability of patient information, such as laboratory test results (Leape LL, 1995).

Evaluation of a POE system with clinical decision support found that it decreased the rate of nonintercepted serious medication errors by more than half, although this decrease was larger for potential ADEs than for errors that actually resulted in an ADE (Bates DW, 1998a).

Alert/reminder functions in POE with clinical decision support usually take the form of a computer-generated message that the clinician views at the workstation. Some alert systems are even capable of automatically notifying the patient’s covering physician via his pager that an alert is present (Kuperman GJ, 1996). Examples:

- **Prophylactic antibiotic use:** Reminder system for peri-operative antibiotic use for those operations where antibiotics were indicated had the effect of improving such antibiotic use and reducing the rate of surgical wound infections (Larsen RA, 1989).
- **Abnormal laboratory tests:** Alerts regarding rising creatinine levels (deteriorating renal function) in inpatients were shown to lead to more prompt adjustment of drug dosages and better preservation of renal function (Rind DM, 1994).

<u>Timely Care</u>

A study of critical laboratory results in a large academic tertiary care hospital without POE/clinical decision support has documented that for 27 percent of cases an appropriate treatment was ordered only after five or more hours, in part due to difficulty communicating critical results directly to the responsible caregiver (Kuperman GJ, 1998).

Coping with Exploding Medical Knowledge

Medicine lacks an information infrastructure to efficiently connect new medical knowledge to those who must apply that knowledge and much of the knowledge that professionals retain from their education quickly becomes obsolete (Weed L, 1997). Even when new knowledge is presented to physicians in continuing education programs it frequently does not lead to changes in behavior – habits are hard to break and the new information is disconnected in time from when it will be needed (Berwick DM, 1996). Finally, the best-trained physician cannot hold in his head all the necessary information about his patient and the relevant medical literature for every decision. POE systems with clinical decision support, therefore, can fill this gap by bringing essential information to the physician in real-time at the point of care.

Doing the Right Things (Appropriate Care)

Systems that simply presented physicians with the results of a patient's lipid test analysis saved the physician time in data retrieval and appeared to enhance compliance with lipid protocols even though the system did not present guideline information (Elson RB, 1997).

An early landmark study at the Regenstrief Institute evaluated the effect of a POE system with 390 embedded clinical protocols, finding that physicians detected and responded to twice as many events when given computer recommendations as when not (McDonald CJ, 1976).

A POE system with capability to critique the ordering of abdominal radiographs (KUBs) was studied. The system would present real-time, evidence-based critiques in two situations; when a KUB was likely to have a low probability of providing useful information, and when an alternative view was more appropriate given the clinical circumstance. The study found that providers were reluctant to cancel their orders but were willing to change orders to more appropriate tests. The system reduced the number of inappropriate radiographic films (Harpole LH, 1997).

Coordination of Individual Care

Especially when ambulatory and inpatient systems are linked, POE systems with a computer-based patient record allow for better coordination of care between multiple inpatient caregivers and between inpatient care and outpatient follow-up.

Preventive Care for Individuals

POE with clinical decision support can trigger age- and situation-specific preventive care reminders. A study in an ambulatory care setting found that physicians who received computer-generated reminders for influenza vaccination vaccinated eligible patients twice as often as did the control physicians (McDonald CJ, 1992).

Aggregate Information to See the Bigger Picture ("Care Management Support")

Capturing a patient's clinical information in a computer-based patient record allows for more than the improved care of that individual. By aggregating multiple encounters and multiple clinical records, analysis is possible to:

- Guide internal process improvement efforts.
- Measure and track treatment intervention outcomes, including functional status.
- Improve the care of covered populations with disease management programs.
- Provide external accountability to purchasers, accreditation entities, regulators, and health plan contractors (Bates DW, 1999c).

<u>Controlled Costs</u>

Better adherence to care pathways improves the efficiency of care, as do more complete and more accurate patient records. Systems that simply presented physicians with previous test results on a patient reduced the subsequent ordering of those tests (Tierney WM, 1987). Computerized display of charges has been shown to affect physician-ordering behavior in some studies (Tierney WM, 1993) but not others (Bates DW, 1997).

Redundant tests are those that follow other tests of the same type, that can be prospectively identified, and that have little chance of yielding clinically important information (Bates DW, 1998b). A POE system with capability to critique the ordering of redundant laboratory tests found that 69 percent of tests were cancelled in response to the critique and close to half of the critique overrides appeared to be justified based on chart review (Bates DW, 1999d). Such systems promise to reduce costs and mitigate the great number and the expanding complexity of laboratory tests that produce an information overload for clinicians faced with masses of data rather than information (Place JF, 1994).

Studies at Brigham and Women's Hospital have found that laboratory use varies widely among physicians, without demonstrated relationship to the quality of care provided. Such variation brings into question whether tests are used appropriately. Studies of test ordering have found that a substantial proportion of diagnostic tests in teaching hospitals may be unnecessary. A retrospective cohort study of over 6,000 adults discharged from a large teaching hospital was conducted to identify the proportion of common diagnostic tests that appeared to be redundant. Researchers found that for some tests an important proportion (almost 10 percent) are repeated too early to provide useful clinical information and in their opinion, most such tests might be eliminated using computerized critiquing systems (Bates DW, 1998b). In another study at the Regenstrief Health Center, the computer displayed, at the time of order, the probability that the test would be positive for the main abnormality being assessed. The physician could then cancel the order if desired. Charges for the eight tests included in the study were almost nine percent less for the intervention patients, compared with control patients. The largest reductions were for serum electrolyte levels and complete blood cell counts, the two most commonly ordered tests (Tierney WM, 1988).

The same conclusion was drawn from a study directed specifically at tests performed to monitor blood levels of digoxin for inpatients treated with that medication – only 16 percent of tests were judged appropriate and daily routine monitoring accounted for 78 percent of inappropriate tests (Canas F, 1999). Potential factors that contribute to redundant ordering by physicians include difficulty in determining when the last test was done, miscommunication as to whether a test was ordered, inadequate education as to the proper testing intervals, and disagreement with recommendations in the literature.

Finally, POE systems with clinical decision support are able to issue reminders about the indications or requirements for use of certain expensive medications, and make suggestions for drug substitution, where appropriate.

In What Ways Have Physician Order-Entry Systems Changed the Work of Physicians?

Where enhanced POE systems have been successfully implemented, physicians generally see the system as saving them time in the long run, thus enhancing productivity (Sittig DF, 1994; Lee F, 1996; Teich, 1996). Some of the features responsible for this favorable impression include:

- Off-site checking of results and order entry
- Ability to view trend data without having to search through records
- No need to hunt for patient record to write an order
- No need to write out routine orders (like admission orders), given the availability of quick orders and order sets (Payne TH, 1999). System can also generate related “corollary” orders automatically; for example, in response to an order for intravenous vancomycin, the system might suggest an order for serum creatinine twice per week (Overhage JM, 1997).
- System may automatically suggest medication dosage calculations based on age, sex, weight, lab values, etc.
- Less need to repeat tests due to lost results
- Fewer calls to the laboratory and other ancillary services for test results
- Decrease in the number of orders initiated but not completed (due to automated follow-up)
- Fewer instances where order is not understood and needs to be clarified
- Easier to know in what forms and strengths a medication to be prescribed is available
- Quality assurance monitors can be educational and private
- Orders are executed faster

Even in situations where POE has been successfully implemented, barriers have been encountered, such as added time or inconvenience (these can be mitigated to some extent by physicians’ involvement in the implementation solution. Some of those barriers include:

- The need for some users to acquire basic computer skills
- More time required entering orders in some systems
- A closer adherence to a facility’s policies and procedures – conflicts between policy and practice may be exposed with the addition of POE and consequent removal of a buffer (i.e., clerk) between physician orders and required policy/procedures. This means rules have to be followed more closely or policies revised. Hopefully, implementation will create the impetus for modifying policies/procedures to be reasonable and realistic, and incorporated into the automated clinical decision support.
- Rounds may be interrupted to write orders if mobile technology is not used (Payne

TH, 1999, Ash JS, 1999). Systems that incorporate PDA/wireless technology or "laptops on wheels" liberate physicians from having to seek out a free workstation.
- ♦ A perception that less time is available to spend with patients, especially where the system may not be enhancing productivity (Weiner M, 1999).

The POE system may be seen as altering the traditional means of care and, in teaching institutions, medical training. Adapting to such changes can be a barrier, as outlined below:
- ♦ POE with built-in order sets and clinical pathways changes the way medical students learn by practicing the handwritten generation of orders specific to a patient. Practicing physicians may also perceive the system as a crutch that dulls their clinical skills through "cookbook medicine." (Ash JS, 1999).
- ♦ Some physicians express concern about de-intellectualization of their work while others find involvement in development of a facility's standardized, evidence-based order sets intellectually challenging.
- ♦ Likewise, some see POE systems as a de-humanization of care while others see POE systems as liberating them from time spent on routine tasks thus allowing more time for addressing the unique care needs of individuals through face-to-face interaction).
- ♦ Greater awareness of charges or cost may influence ordering practice.

In What Ways Have Physician Order-Entry Systems Changed the Work of Nurses?

Nurses generally use the POE system to extract and implement orders, but they do enter some orders directly, e.g., diet and management of IV lines (Weiner M, 1999), and voice orders from physicians. Although it is hard to generalize given the diversity of systems studied, the following summarizes some of the observations to date:
- ♦ Like physicians, some nurses have needed to acquire basic computer skills
- ♦ Nurses often perceive that they have more time with patients due to enhanced productivity (Lee F, 1996, Weiner M, 1999), although this may not be true when a system is first introduced or when they see a need to clarify medication orders modified by the pharmacist (Payne TH, 1999). Enhanced productivity is achieved through:
  - ➢ automatic stop orders that cut down on excessively prolonged use of certain treatments, e.g. prophylactic antibiotics
  - ➢ a reduction in time wasted carrying out duplicate orders for the same medication or test
  - ➢ greater standardization of orders, lessening the need to understand and adhere to diverse regimens and schedules with no proven advantage for one over the other
  - ➢ improved spacing of tests and procedures, thus reducing time devoted to carrying out redundant orders
  - ➢ less need to enter voice orders into the system as physicians gain access to the system from other floors and remote locations
  - ➢ less need, due to integrated record-keeping, to repeat patient assessments, e.g. questioning for allergies, patient body weight, vital signs, performed recently in

another unit or emergency department before transfer

- Nurses appreciate that orders are usually executed faster and patients receive better care (Weir C, 1996)
- Depending on system design, nurses may find it difficult to know when a new order has been written into the system, a special concern with respect to “stat” (ASAP) orders
- Off-site entry of orders by physicians is sometimes seen by nurses as detrimental because it reduces opportunities to discuss face-to-face with the physician the care of patients on the floor (Payne TH, 1999); in other situations no change in ease of access to physicians was perceived (Weir C, 1996)
- In situations where physicians were resistant to entering orders and saw voice orders as a way to circumvent the POE system, nurses have had to guard against inappropriate voice orders

In What Ways Have Physician Order-Entry Systems Changed the Work of Pharmacists?

POE systems generally reduce the pharmacist’s time to fill drug orders. The order is interpretable and even if the physician needs to be contacted for clarification, the identity of the physician is not in question as it might be with an indecipherable signature. Decision support reduces the need to correct medication orders and assures a greater adherence to the formulary, thus simplifying and standardizing the dispensing process. If the POE and pharmacy systems are integrated, one avoids re-entry of the order into the pharmacy system. In either case, pharmacists still need to devote time to editing physician orders when appropriate, and then assuring that edits are understood by nurses who will administer the medication (Payne TH, 1999).

POE systems are likely to result in a changed role for the hospital pharmacist:

- The pharmacy department in the hospital generally takes responsibility for the construction of the order tables governing medication alerts and rules of the POE system. This new role for pharmacists has become a demanding and rapidly expanding career path.
- In some cases the POE system has been linked to pharmacy automation where the pharmacist has a role in system verification.
- Because some POE systems also give pharmacists much more access to patient clinical data, they are questioning orders before filling to a greater extent than previously done.

In many cases the POE systems are allowing an increase in the role of the pharmacy technician and a more clinical role for the pharmacist.

Chapter 3. Assessing the Business Case for Computerized Order Entry

Given the preceding profile on the tremendous potential of POE systems for improving patient care, one might think this to be a moot issue. In fact, the question is often not an easy one to answer, with several caveats and financial, institutional, and strategic considerations. This guide aims to outline these considerations in an orderly way as noted in the attached algorithm (see Figure 1).

Financial Considerations

Return on investment for POE systems has been difficult to assess, and cost-benefit has not generally been examined in a rigorous way. These systems are expensive and, at present, cost savings and return on investment need to be better documented (Weekly J, 1999). Intuitively, one would expect that by increasing compliance with care pathways and payer rules, costs would decrease and revenue might increase. With increasing penetration of managed care and greater expectations by plans and providers for "real-time" data, early adopters of the technology are banking on there being a good return on investment (Appleby C, 1997, PACCP, 1998). Others are not bothered by the lack of evidence for return on investment, seeing POE systems as a contribution to performance, i.e., the cost of doing business, and not as a dollar cost that needs to be offset (HIMSS, 1996). This may prove true as large purchasers of healthcare, e.g. the Leapfrog group (described earlier), exert pressure on providers to adopt POE systems and as accreditors consider the adoption of standardized reporting of clinical performance measures that can only be obtained through clinical record abstraction – a costly proposition if done manually (QuIC, 2000).

Costs may be more than estimated, especially if one only factors in the cost of the system purchase (Massaro TA, 1993). The actual implementation cost may well double the purchase price of a commercial system once other costs are accounted for, e.g. extra workstations, network upgrades, training costs, extra staffing needed to cover care-giving staff during training and implementation, and staff time to modify the software to accommodate site-specific clinical rules and customized user interfaces. A hospital with 250 licensed beds can expect to spend from one to five million dollars on system purchase and an equivalent amount on implementation. Costs rise in proportion to size (number of expected simultaneous users).

Institutional Considerations

While study is needed on the kinds of institutional characteristics that lead to successful implementation of POE systems, experience to-date suggests the following factors favor success (McDonald CJ, 1996; PACCP, 1998; DeLuca JM, 1996):

- A relatively high degree of interface between physicians and the institution (hospitalists and full time medical staff would increase this).
- A history of relatively high physician exposure to computer systems (e.g. results reporting, Internet/literature searches, e-mail).

- Medical staff is supportive of, or open to assessing the need for, a POE system.
- The capability of staff in nursing, pharmacy and information systems departments exists to plan and implement a POE system.
- Workflow redesign and process improvement efforts that antedate purchase of a POE system.
- Prior development of an information technology strategic plan and supporting budget that is aligned with the organization's business goals.
- An organization with a history of leadership and commitment for quality improvement, where information technology is seen as a means to an end, rather than an end in and of itself. Additional discussion of the importance of leadership can be found in the discussion of implementation in Chapter 4.
- A local healthcare market that would likely reward investments in information technology.
- An organization with sufficient capital and no anticipated depletion of capital as a result of consummation of a merger or acquisition of another facility.

Strategic Considerations

- Existing systems in many organizations are focused on billing and other administrative functions – inadequate to improve clinical quality or keep up with multiple changing health plan requirements.
- As a whole, the healthcare industry has tended to invest relatively little in information technology compared to other sectors of the economy, but this is beginning to change (Gawande AA, 2000a).
- POE holds the potential to help institutions deal with two challenges of health reform: quality improvement and documentation of quality while containing cost.
- The incompatibility of numerous proprietary systems has held back progress towards better linkages between information systems. Final implementation of the Health Insurance Portability and Accountability Act (HIPAA) will create "messaging" standardization, primarily with respect to financial transactions.
- Also holding back progress has been the need for richer computer coding schemes to provide the level of clinical precision that is needed for robust clinical quality measurement.
- Finally, some have suggested there might be an increasing legal liability associated with any decision not to move forward with POE/clinical decision support (Eclipsys, 2000).

Several Caveats

One must keep in mind that the studies demonstrating the benefits of POE systems have been conducted primarily in institutions with possibly quite different characteristics than the reader's. Young physicians in an academic medical center – compared with older physicians in a community setting – may more easily adapt to POE (Drezner JL, 2000). Homegrown systems tailored to a research institution's work processes and culture may differ in important ways from one being considered for purchase by a service-focused organization. Remember too that the innovators were able to derive research as well as service benefit from their systems and could therefore more easily justify the investments in their systems.

Another caveat relates to the fact that, at present, few if any commercial POE products undergo any pre-market testing similar to the evaluation of a new medication or medical device (Gawande AA, 2000b). These are very sophisticated systems that, like medications and medical devices, have the potential to cause harm as well as benefit (ISMP, 2000). For example, a POE system with clinical decision support could cause an error by incorporating an incorrect or outdated clinical rule. Some have even advocated for U.S. Food and Drug Administration regulation of the more complex systems (Miller RA, 1997).

Chapter 4. A Purchaser's Guide to Computerized Physician Order Entry

In this chapter, important features and considerations are outlined for the healthcare executive who has decided to invest in a physician order-entry (POE) system.

User Friendliness

Physician acceptance of POE is critical. The first step is getting physicians to appreciate that medical risk – risk to both patients and clinician – may be reduced by use of POE. Early studies found that order entry with a POE system could be slower than pen and paper, thus making acceptance by physicians more difficult (Bates DW, 1994b). Physicians may see their time as too valuable to spend entering data. While more time consuming when single orders are entered, POE tends to save time when ordering standardized groups of medications, as in post-operative orders. An understanding of this up front may help decrease criticism as a POE system is implemented. As voice recognition functionality improves, it will help overcome this current difficulty. Efficient capture of physician information in coded form will also allow electronic medical record systems to gain a wider foothold (McDonald CJ, 1997). Ensuring that your system has the right features can help address physician concerns (McDonald CJ, 1986; McDonald CJ, 2000; Lee F, 1996). Among them:

<u>Ease of use</u>

- The system should be as intuitive as possible, with minimal training necessary.
- Physician interface screens should be consistent from application to application and at all locations.
- System should allow physicians to write orders at the level of specificity to which they are habituated (traditional "clerk" order-entry systems often required more specification and detail for billing capture than what a physician would normally write).
- System setup should allow flexibility in adapting screens and fields to the local work pattern so as to minimize the number of workflow changes necessary to adapt to a new POE system.

<u>Speed</u>

- There should be sufficient processing power and network capacity ("bandwidth") to ensure high-speed screen turnover (sub-second response time).
- Physician screens should be tailored specifically for physicians, e.g., avoiding generic screens with inappropriate fields for physicians.
- Decision support features of the POE should be on the "front end" of the order process to avoid wasted energy by the physician, e.g. it is better for the system to issue an alert because of a medication incompatibility after the physician completes a few fields on the first screen, than to issue the alert after three screens of information have been entered.
- There should be flexibility for the system administrator to eliminate system alerts and reminders with little or no clinical significance.

Productivity

- Systems with only narrow applicability will be viewed less favorably. Physicians are more likely to adopt a system that has an intelligent interface with other systems, e.g. laboratory and pharmacy, allowing the system to check a medication order against relevant lab values. As a general rule, POE should never be separate from the pharmacy order system.
- It is important that the system include medication orders and be capable of medication order checking, e.g., dose range checking, drug-drug interaction, and drug allergy checking.
- Decision support should not only enhance quality of care but should seek as a parallel goal a gain in physician productivity.
- The more the POE is enhanced with clinical decision support, the better for physicians. The alerts, reminders and suggestions offered by the clinical decision support are what will make the data entry worthwhile to physicians.
- Order sets based on clinical guidelines that encompass care from admission to discharge, and include automatic advancements toward discharge based on predefined criteria, may save physician time as well as streamline care and shorten hospital stays.

Under the Hood

Although this area is still evolving, it is advantageous for the system's structure, definitions and coding to be in compliance with industry and national data standards (e.g. Health Insurance Portability and Accountability Act [HIPAA], and Health Level-7 Standards [HL7]). This will help assure future linkage and data exchange capability with third party payers, regulators, accrediting bodies, and other providers for coordination of care.

Insist on testing a working system before you buy. Come prepared to test whether laboratory, medication, and nursing orders that should be flagged as inappropriate are done so. For example, will the system flag an order for cisplatin 204 mg IV for one dose to a 26 Kg child, or an order for tobramycin 120 mg IV every eight hours for a patient with a creatinine clearance of 10 mL/min (ISMP, 2000)? Other features to look for include (Sittig DF, 1994; Aydin CE, 1997; Teich JM, 1995):

Security

- Is the system's manner of accommodating electronic signatures legal in your state?
- Is the system able to handle orders that require countersignature, e.g., verbal orders and medical student orders?
- If you train medical students, can the system put a hold on student-modified orders until properly countersigned?
- Can the system accommodate robust security measures that grant access to select parts of the system based on job function and/or individual security clearance?

Flexibility

- Can the system handle interrupted sessions without data loss? For example, the busy physician who gets called away before a session is complete.

- How well does the system accommodate scenarios that differ from routine inpatient orders so as to maintain efficient workflow, e.g., patient transfer, post-op, pre-admission? Pre-admission orders, for example, need to be suspended from execution until the patient has been admitted.
- Is the system able to integrate inpatient and outpatient records, e.g., transfer a list of outpatient medication orders to inpatient status?
- Can the system recall orders from a previous admission?
- How difficult or costly will it be to link the new system to legacy systems?
- Does the system build, through POE and other input, a computer-based patient record that can form the basis of a data warehouse that can be used to measure performance through retrospective analysis of aggregate clinical data?

Safety

- What system checks exist to help ensure that the system minimizes the introduction of new sources of error? For example, is it possible to invoke (sometimes-necessary) exceptions to automatic medication stop orders? Is confirmation sought on automatic medication stop orders?
- What safeguards exist to verify that the orders being entered are for the correct patient?

Evaluation

- Has this system, or components of this system, ever been subjected to a controlled trial to assess efficacy and risk in a scientifically rigorous manner? Currently, very few systems have been studied in this manner.
- Can the system provide reports of the frequency and types of overrides of program defaults by users?

Vendor Considerations

You should ask your potential vendor a number of questions:

- Will the vendor continue to be available to answer questions and provide support following purchase? For an extra fee?
- How can you contact and interview others who have purchased the same system?
- Has the vendor formally adopted a code of good business practices?
- How will currency of the system be maintained, especially with respect to clinical knowledge base and rules for clinical decision support? Who will do it and at what cost? For example, how are new drug-allergy-alert data added to the database?
- If you are purchasing a subscription service (e.g. remote Web-based software) with co-development partnership, are the business strategies and ownership structures of your two organizations compatible?
- How long has the vendor been in business and what is the long-term viability of the vendor’s business (purchasing POE systems often means a long-term relationship with the vendor)?
- How is the quality of vendor-supplied alerts judged, and by what criteria?

Chapter 5. Implementation Guide for Computerized Order Entry

Before Installation

Leadership: Successful implementation depends on strong medical and administrative leadership (Garibaldi, 1998). Top executives of the organization must give their unequivocal support to the planning, design, and implementation process or it will likely fail (Weir C, 1994). This is not something that can be delegated exclusively to the chief information officer (CIO).

Where possible, it would be beneficial to appoint a medical information officer (MIO) who is a well-respected clinician with interest and knowledge related to information systems. This individual preferably should have interpersonal, teaching and leadership skills in addition to a working technical knowledge of POE systems. The time commitment required of the MIO makes it difficult to expect this person to volunteer his or her time, and most organizations with such a position must provide monetary compensation for this part-time work that is usually assumed in addition to continuing part-time clinical duties. The MIO will provide the medical leadership and assist with system designs that will be seen to be user-friendly and result in timesaving for physicians (Bates DW, 1994c; Lee F, 1996).

Leaders need to address several themes of resistance found among physicians, including fear of loss of rapport with patients, a non-specific uneasiness about artificial intelligence, distrust of machine capabilities, the perceived burden of data entry, and fear of loss of control over patient decisions (Eclipsys, 1999).

Finally, interdisciplinary collaboration between physicians, nurses, and pharmacists must occur for all processes (McBride 1999).

Workflow: It is important to re-engineer workflow for greater efficiency before any system is bought or implemented. This will help minimize subsequent workflow changes incorporated into the new system and thereby reduce any resentment toward the system consequent to those adjustments.

Oversight: A multidisciplinary oversight committee should be established to guide the customization of the POE system and take responsibility for assuring that clinical content and decision rules are kept up to date with current clinical standards. Customization at the organization level will include standardization of screen templates and terminology and should involve input from the entire healthcare team that will use the system. Customization at the department level should accommodate to the greatest extent possible the local patient care process. This will help foster an interdisciplinary team spirit and functionality. The medical staff in particular needs to be engaged in helping to develop the “look and feel” of the system, or subsequent physician buy-in will be more difficult.

This oversight committee should not supplant, but rather interface with, other existing expert committees, such as the pharmacy and therapeutics committee with oversight of the institution's medication order and delivery process.

Policies and Procedures: New computer systems have a tendency to expose an organization's latent procedural weaknesses. For example, there may be conflicts between policy and actual practice. In some cases the policy is unrealistic or out of date. In other cases practice patterns have deteriorated through lack of attention to sound policy. As the new POE system is tailored to your institution, it is critical that these conflicts be resolved; if policy and practice are in conflict, the POE system will bring the discord to light because it can only support one or the other, not both. Bottom line – make sure policies are flexible and sensible.

Special orders: It is important to determine how orders from other than the primary care physician will be handled. Provisions for countersignature of nurse-entered voice orders need to be made. A procedure needs to be in place for handling medical student orders. Finally, it must be decided whether orders from consulting specialists will be executed or required to have a countersignature.

Downtime: Procedures to be followed during planned downtime or unplanned system failure need to be developed, to include having backup manual systems in place and written procedures to be followed when a system that has been down comes back up. Those procedures need to address such things as whose responsibility it will be to enter the information processed manually during the downtime, e.g., handwritten orders. (Sittig DF, 1994; Weiner M, 1999).

Contracts: It is important to have carefully constructed and executed contracts with the vendor, to include a master agreement, license agreement and maintenance and support agreement.

During Installation

Convenience: Computer workstations should be placed in convenient locations and there should be ample quantities of them so that caregivers don't have to search or wait for access to one. Convenient access means allowing for ordering at the bedside when staff make rounds. This can be accomplished by nearby fixed workstations, mobile workstations, or handheld/wireless technology.

Training: Minimize up-front training in favor of just-in-time, on-the-job training (Ash JS, 1999) and remember to plan for lost productivity during training – this may mean adding more staff to maintain workflow. If possible, use physicians who have taken an early interest in the system to train other physicians.

Testing: The medication ordering system must be tested to ensure that outputs accurately reflect input information.

Phasing: From a practical standpoint – cost spread, training demand, and staff adaptation – one often elects to implement the system in stages (Aydin CE, 1997; Weiner M, 1999). Staging can be done by implementing the full system sequentially in the various service units, by phased implementation of system functions in all units simultaneously, or a combination of both. Experience suggests that it is generally preferable to fully or partially implement the system simultaneously in all units to avoid problems with order execution when patients transfer from one unit to another, hassles associated with different ordering procedures when physicians move from one unit to another, and ancillary units having to process two kinds of orders depending on the source. Phasing in by function needs to strike a delicate balance between providing too little functionality and an overwhelming amount of functionality. Either extreme invites physicians and other users to prejudge the final system and risks the cooperation needed for change. Some level of decision support is needed early on to help physicians appreciate the productivity and quality benefits of the system. One approach used by hospitals has been to start with information retrieval only (no order-entry), to include available patient information stored in electronic format, e.g., test results, procedure notes and discharge summaries, and information of interest to physicians and other caregivers, e.g., operating room schedule, continuing medical education events, and Internet searching. This strategy increases exposure of medical staff to computers and demonstrates the value of rapid access to information before engaging them in an order-entry process.

After Installation

POE systems are almost always a work in progress after installation. Expectations of a perfect turnkey system are not realistic and should be addressed as part of the pre-installation orientation and training. Technical support should be readily available, preferably on the floor – 24 hours a day, seven days a week (Weir C, 1995, Payne TH, 1999). It is important to solicit user input continuously, perhaps through the system itself, and then to provide timely feedback and system modifications accordingly. The oversight committee needs to troubleshoot problems and work out procedural issues (Massaro TA, 1993).

The focus of any aggregate analysis of data captured in the new system should be on learning for performance improvement. To do otherwise could easily jeopardize the buy-in by professionals on whom you are counting to use and trust the system.

Finally, it is important to remember that the introduction of any new system carries with it the potential to introduce new sources of error. If the system is seen as a panacea for error, for example, it may lead to complacency. Institutions that adopt POE technology must remain vigilant in their patient safety efforts and, if they do this, they will most likely find that their investment, on balance, greatly advances patient safety and quality of care.

Chapter 6. Examples from the Field

Vignette: Martha Jefferson Health Services

Martha Jefferson Health Services (MJHS), Charlottesville, Virginia, is a nonprofit community medical center with 156 staffed beds, roughly 9,000 inpatient admissions per year and 87,000 outpatient visits per year. MJHS is in the process of implementing a computerized physician order-entry (POE) system. The Chief Information Officer had previously worked for a vendor of hospital information systems so he was familiar with established vendors of POE systems. Leadership decided to invest in POE as a means to improve quality and control costs. An oversight committee that included physicians drew up specifications, and a request for proposal was sent out to vendors. Proposals were evaluated using a matrix to cross-tabulate features and vendor systems. A site visit was paid to the top contenders for hands-on demonstrations. References were requested and checked. Finalists included Cerner Corporation, McKessonHBOC, Ameritech, Bell Atlantic, and First Data. A contract was eventually signed with Cerner.

An implementation plan was drawn up that extends over five years. Cerner reviewed the descriptions prepared by hospital staff of “current state” and “future state” and identified misconceptions in expectations of the system. One aim was to focus on physician users and score an early “win” for the medical staff. Their strategy was to build a clinical data repository that would allow physicians to retrieve electronically patient record components and results of tests, before initiating physician order entry. This repository grew to include all laboratory results, all radiology notes, cardiology (e.g. EKG interpretations), and all transcriptions. This approach appears to have worked – physician use for information retrieval has grown steadily and calls to the laboratory for results have decreased.

Although orders are not yet being entered, the implementation to date has been relatively smooth from an organizational standpoint. Most staff members were relatively computer savvy before purchase of the system. Younger physicians have not only accepted it; they seem to expect automation because they came to depend on it where they were trained. The oversight committee has been successfully addressing policy issues related to implementation. Where they have discovered conflicts between established policy and actual clinical practice, they have generally allowed systems customization to track practice rather than policy. The committee has taken the stance that the hospital should not try to implement too much all at once, believing that it is important to make the initial features work well since some users will undoubtedly judge the entire system, including yet-to-be-installed components, by their first impressions.

The technical aspects of preparing for the physician order-entry phase, however, have taken longer than anticipated. This has involved customizing all the interface screens and programming the clinical rules to conform to local standards and customs. The tight labor market has made it difficult to hire the necessary expertise to carry out this co-development of modules. Use of existing staff from various departments to help with the customization has left those departments sometimes short-staffed. To allow physicians to connect with the system from their offices, the hospital has expanded the wide-area-network to many additional sites. An upgrade in network bandwidth will be required to keep the speed of the system at acceptable levels as new users are added.

The added costs of module customization, network expansion (workstations, connections, and bandwidth), interfaces with legacy systems, hardware for security, and staff training have effectively doubled the cost of the system when compared to the purchase price for the components supplied by the vendor.

Vignette: North Mississippi Health Services

North Mississippi Health Services (NMHS), Tupelo, Mississippi, is a nonprofit integrated delivery system that serves 22 counties in northern Mississippi, western Alabama, and western Tennessee. It operates five acute-care hospitals, six regional dialysis units, three nursing homes, a home care agency, and more than 40 physician offices. NMHS has focused on development of a computer-based patient record rather than computerized physician order-entry (POE) *per se*.[1] Although POE was always a feature included in the plan, the system has been built in stages without being anchored on POE. A strength of the system has been its demonstrated ability to support care management decisions through retrospective analysis of aggregate clinical data.

Like most hospitals and health systems, the initial information system investment centered on billing needs. A new strategic plan was drawn up in 1994 by the Clinical Information System (IS) Steering Committee that includes physician-user representatives. The strategic initiatives selected were computer-based patient records, enterprise-wide integration of data, managed care readiness, and technology enhancements. The Steering Committee approves and sponsors projects headed by a project manager who is held administratively accountable. The project manager oversees a project team that includes an IS department representative, user community representatives, a physician, and representatives from affiliated institutions. Each team follows a standard process that includes generating and issuing a request for proposal (RFP), preliminary and in-depth assessments before vendor selection, and negotiations prior to contract execution. The team oversees the method and execution of staff training related to the new system component. End-user members of the team develop the policy and procedures for the new system component, including the time frame and method for transitioning from manual to automated process.

NMHS began using the Technicon Data Systems (TDS) HealthCare 4000 operating system that was subsequently upgraded to the TDS 7000 Series, sold by Eclipsys Corporation. Features of TDS 7000 include registration, order entry, result reporting, medical record chart management, medication charting, pharmacy, nurse notes, care plans, physician office and home links, discharge summaries, medical records abstracting, radiology film tracking and automated card file, vital signs, intake and output. The only clinical information items not currently in the computer-based patient record are some inpatient physician progress notes, family medical clinic physician notes, images, intra-operative documentation, consent forms, and physiologic data from bedside equipment.

Physicians, nurses, pharmacists, laboratory technicians, respiratory therapists, dieticians, and others enter data using a light pen or mouse to select items from menu screens. The system promotes productivity of healthcare professionals – ambulatory care notes, for

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1 Bozeman TE, Harvey K, Jarrell I, et al. The development and implementation of a computer-based patient record in a rural integrated health system: North Mississippi Health Servises, Inc. Proc Third Annual Nicholas E. Davies CPR Recognition Symposium (CPRI Institute), 1997.

example, are accessible and provide the admitting physician with a summary of recent events. Duplicate requests of the patient to list home medications and drug allergies are avoided by automating this information in the permanent patient record. Having mobile radio-frequency terminals in the emergency department and patient care areas enhances physician and nurse access to the system. As physicians make rounds they are able to access each patient's most recent test results or surgical dictation. The current system has automated patient records and access from more than 100 different buildings and sites in 26 cities in a two-state area. Electronic discharge summaries are automatically communicated and printed in the hometown, referring, attending, and consulting physicians' offices.

The NMHS system provides real-time and retrospective clinical decision support, as well as care management support. Programs that screen for drug-drug and drug-food interactions and drug allergies provide real-time active support. Another program screens for "stat" orders of "tracer" drugs (e.g. antidotes) and selected chemistry lab values and alerts the pharmacist who investigates to determine if an adverse drug reaction has occurred. The system also checks physicians' medication orders by calculating dosages based on the patient's weight. Passive support is provided by online access to medical and drug reference information. The system supports the pharmacist in providing individualized pharmacokinetic consultation and anticoagulation consultation by supplying access to blood chemistry results, serum drug concentrations, and clotting parameters. Finally, the system incorporates critical pathways to prospectively determine the patient's length of stay and required services. These care guides are developed based on retrospective analysis of aggregate data collected by the system. Computer-based patient record data are exported to decision analysis software that includes risk-adjustment capability (e.g. Iameter) and from this analysis of utilization, length of stay, and patient outcomes, a best practice model is created. The system also provides support to nursing supervisors for decisions related to staffing needs – by capturing admitting diagnoses and anticipated lengths of stay the system helps supervisors prospectively calculate patient acuity.

Vignette: Wishard Memorial Hospital

The Wishard Memorial Hospital, located on the Indiana University Medical Center (IUMC) campus, Indianapolis, Indiana, has a "home-grown" computerized physician order-entry (POE) system that had its beginnings in 1984 at the Regenstrief Medical Center.[2,3] A strength of this system is its ability to link numerous sites, both inpatient and outpatient. IUMC encompasses 30 sites in Indianapolis, including four hospital/medical centers, five public health clinics, two neighborhood clinics, and 19 freestanding clinics.[4]

The POE system is linked to a computer-based patient record system that includes: laboratory and pharmacy information; vital signs and nursing observations; electronic documentation from transcription of admission, discharge and visit notes, and surgical pathology, radiology and nuclear medicine reports; EKG tracings and interpretations; and administrative data related to admissions, transfers and discharges. Linkage of the various systems is accomplished using Health Level 7 (HL7) as the message standard.

Thoughtful implementation was considered a key success factor from the beginning. To be appealing to physicians, the system was designed to add value to physicians' work, fit the local care process, be clinically "smart," fast, flexible, and user-friendly. To be clinically "smart" the POE was built on an electronic medical record system that would allow the physician to easily retrieve and organize patient information. At sites where the POE system has been in place the longest, physicians have been entering diagnostic test orders for up to 15 years. On hospital floors physicians from all services enter all patient orders and problem lists directly. Physicians on the internal medicine service also enter discharge notes directly.

Orders are entered by choosing the appropriate items from screen menus using the mouse, the arrow keys, or by typing the first few letters of an order name, causing the system to return a menu of orders beginning with those letters. Complex order instructions can be created using templates with fill-in-the-blank options.

Online passive decision support is provided by test results reporting in either flowsheet or graphical formats, medical textbooks, display of costs or charges associated with orders, full-text of popular medical journals, pocket rounds reports, patient flow charts, formulary, and pager/phone directories.

Active decision support consists of system alerts for drug interactions and allergies; suggestions regarding specific dosages using weight-based calculation, duration of treatment, safer or less expensive diagnostic and treatment options, and corollary orders that would be logically coupled with invoked orders; and reminders about preventive

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2 McDonald CJ, Overhage JM, Tierney WM, et al. The Regenstrief Medical Record System: a quarter century experience. Int J Med Informatics 1999;54:225-53.
3 Tierney WM, Miller ME, Hui SL, McDonald. Practice randomization and clinical research. The Indiana experience. Medical Care 1991;29:JS57-64.
4 McDonald CJ, Brill JH, Johnson K, Stead WW, Pincetl P. Session 18. Implementing a physician order-entry system: perspectives from five physicians. HIMSS Proceedings 1996;1:179-188.

interventions and orders encouraged or discouraged by hospital-adopted care pathways (management of heart failure, pneumonia, urinary tract infection, asthma, anticoagulation, and use of blood products).

Leaders and developers of the Wishard system attribute their successful implementation to the following:

- Introducing physicians to the system through patient data retrieval before requiring order-entry
- Soliciting input from users on a continuous basis to gather suggestions and complaints and make system modifications accordingly
- Recognition that clinical decision support has its limitations due to the numerous “gray zones” in medicine
- Adoption of a standard for medical terminology to facilitate the linking of different systems in various departments and facilities

Vignette: Brigham and Women's Hospital

The Brigham and Women's Hospital, Boston, Massachusetts, has developed its homegrown "Brigham Integrated Computing System (BICS) with a strong emphasis on clinical decision support.[5] This hospital is an academic medical center with about 700 beds, admitting over 35,000 inpatients and seeing over 600,000 outpatients annually at four locations. It is now part of the Partners HealthCare System.

BICS runs on a network of over 6,000 microcomputers. The order-entry system was developed in 1992 and has played a large role in improving care and reducing cost through the use of electronic communication, alerts, reminders, and algorithms to promote appropriate care, prevent adverse events, and improve the utilization of resources. These goals have been achieved through pre-existing interdisciplinary emphasis on clinical quality improvement and process evaluation, effective leadership for cultural change, strong organizational support, system design around caregiver information needs, and prompt action in response to solicited feedback from users.

In particular, implementation was made possible by the vocal and consistent support of BICS by senior, respected members of the medical staff. The project team also placed emphasis on use of paid medical information officers – physicians with computer expertise who also practice medicine part-time. As the system was developed, functionality was added gradually, allowing users to adapt to changes in workflow and developers to tailor refinements and future capabilities according to user needs. Designers strove to provide a consistent user interface across all applications to make it easier for users to understand and use newly added features.

Orders on all inpatient services are entered through BICS – the vast majority is entered by physicians with the remainder entered by non-physicians in a primary caregiver role (e.g. midwives and physician assistants), and nurses processing voice orders. Orders can be entered remotely from home or office. Order sets are available to group orders that are logically connected by condition or situation. Physicians may create their own personal order sets. Physicians enter inpatient orders, ambulatory care notes, and patient summaries (longer notes are entered by dictation with modem interface between transcription and BICS). Referring physicians appreciate the increased access to information about their referred patients.

Passive clinical decision support is provided to all caregivers through logical information displays that provide results reporting for almost all laboratory tests and patient studies. BICS displays the charges associated with laboratory tests and radiology procedures. A handbook subsystem provides online access to clinical reference texts, hospital formularies, and tables of normal lab values. A "sign out" feature allows the primary physician to rapidly update a patient summary that is passed to the covering physician –

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5 Teich JM, Glaser JP, Beckley RF, et al. Toward cost-effective, quality care: The Brigham integrated computing system: Brigham and Women's Hospital. Proc Second Annual Nicholas E. Davies CPR Recognition Symposium (CPRI Institute), 1996.

allowing more information, including resuscitation status, to be passed with less effort. The system collects all such summaries for the primary physician's patients and prints them for the covering physician. Acceptance of this feature is high, with over 95 percent of all possible patient summaries viewed and printed daily.

Active clinical decision support is provided, for example, by suggesting default medication doses and frequencies, appropriately modified for the patient's renal function and age, and serving to remind the orderer of standard practice. An inference engine checks new information for a patient against appropriate rules. A new lab result for serum potassium level, for example, causes the engine to check the current lab result against critical values, the previous lab result for comparison and trend detection, and the medication file to check if the patient is on a potentially interacting medication such as digoxin.

If an alert is called for by the rules, a notification processor uses rule tables to decide how to contact the appropriate person using coverage lists. The system also selects the appropriate manner of notification depending on the urgency of the situation (e-mail, screen color change, or in the most serious situations, by automatically paging the caregiver). The alert is fully explained on a special screen when the caregiver signs on, and the alert screen provides an action (order) option menu tailored to the situation. Caregivers are also queried as to whether they appreciated receiving the alert – they respond affirmatively 95 percent of the time. Such alerts have reduced the time to take action in response to "panic" lab values from an average of 2.1 hours to an average of 0.7 hours.

Active clinical decision support capability of the BICS system also:

- Warns if a patient is allergic to ordered medication.
- Checks for interaction between ordered drug and any other drugs patient is taking.
- Warns if patient is already on ordered drug (duplicate order).
- Shows relevant lab results when ordering medications.
- Warns on order if lab test is inappropriately soon after previous test.
- Guides selection of cephalosporin antibiotic, based on indication.
- Guides initial use and cessation of vancomycin antibiotic.
- Guides selection of cost-effective H2 (gastric acid) blockers.
- Warns and/or restricts when daily, weekly, or overall dose of chemotherapy exceeds limits.
- Prompts for "rescue" drugs such as leucovorin when certain chemotherapy agents are ordered.
- Offers suggestions for better alternatives to plain x-ray film of the abdomen (KUB) based on indication.
- Prompts for reason for transfusion and presents relevant lab values.
- Warns when patient on total parenteral nutrition has no new order, as preparation deadline approaches.
- Finds patients who are on intravenous (IV) medications and also taking other medications or food by mouth (suggests conversion of all medications to oral

route).

- Calculates cardiac output and creatinine clearance, where appropriate.

Nurses enter some inpatient orders, manage beds, score patient acuity, and enter patient observations. In addition to features described above, clinical decision support is also provided specifically for nurses, e.g. a drip calculator to help properly set pump rates for IV infusions; and a patient discharge assistant that prints complete discharge details for the patient, including medication instructions in layman's language, home care instructions and follow-up visit arrangements. In the emergency department the system can print problem-specific instructions from the American College of Emergency Physicians for the nurse to educate the patient.

Brigham and Women's Hospital has recently brought automation to their ambulatory care setting, where they now have the capability of computerized prescribing with machine-printed prescriptions.

Vignette: Veterans Health Administration

The Veterans Health Administration's (VHA) Computerized Patient Record System (CPRS) represents an integrated, comprehensive suite of clinical applications that creates an electronic medical record to assist health care providers in performing their clinical responsibilities. Two user interfaces are included: 1) A graphical user interface (GUI) that functions on a clinical workstation; 2) A terminal-based interface designed to work on equipment that predates personal computers. CPRS was designed to resemble a paper chart and includes functional components that are displayed as chart tabs. These tabs include Cover Sheet, Progress Notes, Medications, Labs, Consults, Discharge Summaries, Problem List, Orders and Reports.

CPRS is always available for access by health care providers and may be used by multiple providers simultaneously. Many clinicians review their patients' status from their homes via remote dial-in access. Remotely, health care providers can act on abnormal clinical results by entering medication, lab, dietetic, consult, procedure, radiology, vitals and patient care orders that will be electronically transmitted to the responsible service for immediate action.

<u>Major CPRS Functional Components</u>

- **Patient selection.** Extensive patient selection capabilities allow physicians to build patient lists based on ward, room-bed, clinic appointment, patient's primary provider/attending physician, team and individual patient.
- **Coversheet.** The CPRS coversheet provides a condensed view of pertinent clinical and demographic patient data on one screen. It includes allergies, medications, labs, vitals, appointments/admissions, crisis notes, adverse reactions, warnings, directives and clinical reminders.
- **Order entry and management.** Processing orders in CPRS includes: 1) order entry and order management for labs, medications, diets, radiology, procedures, consults, vitals and nursing care; 2) appropriate holding/processing/status assignment related to user credentials, order signature status and filling package, and 3) event posting. Order storage in CPRS includes a complete, date/time-stamped history of all events related to the order. This includes status changes, ordering, requesting and signatory personnel, related order checks and over-ride reason, flagged order data and various components related to the filling package.
- **Encounter form data collection.** The CPRS GUI enables the collections of encounter form data, including patient education, immunizations, skin tests, health factors, diagnoses, providers, procedures, examinations and vitals.
- **Consults.** Consult ordering/requesting, tracking and resulting can be accomplished within CPRS. Consulting events such as requesting, resulting and significant findings trigger notifications to appropriate health care providers who can then quickly react to the request or result.
- **Progress notes and discharge summary entry and management.** CPRS enables the direct entry or uploaded entry of notes. The note management tools are extensive and support the definition of facility-specific business rules that respect local

authorization policies. The software also supports association and viewing of a scanned document or image with a textual document.

- **Clinical decision support tools.** CPRS supports three different types of decision support: real-time, interactive order checking; notifications that generate patient-specific clinical alerts regarding order entry, consult, radiology, lab, pharmacy, dietetics and admission/discharge/transfer information; and clinical reminders that alert clinicians of regularly scheduled clinical activities that are due. Clinical reminder dialogs support real-time resolution of the reminder, simultaneous capture of discrete encounter data and automatic generation of the associated progress note.
- **Reports.** CPRS enables users to view current and historical data in graphical and textual formats. It also enables access to patient data at remote VHA facilities where the patient had been seen previously.

Parameters and defaults. To allow variation and modification for VHA Health Care Treatment Facilities, CPRS provides a hierarchically structured set of parameters. The parameters can have a user, team, service/section, patient location, division, system and package value. The extensive set of parameters exported with CPRS allows VHA administrators and CPRS users to fine-tune the functionalities and processes specific to their needs.

Information Resources*

Videotapes

"Computerized Decision Support Systems"
Featuring Terry P. Clemmer, MD, University of Utah School of Medicine, and Reed M. Gardner, Ph.D., University of Utah and Latter Day Saints Hospital. Available for purchase from the American Medical Informatics Association (AMIA) (http://www.amia.org)

"Clinical Information: A System for Saving"
Features the system used at Virginia Commonwealth University's Medical College of Virginia Hospital. Available for purchase from the Medical College of Virginia Hospital, PO Box 510, Richmond, VA 23298

Useful Websites*

An online directory of health information system vendors is available from the Healthcare Information Management Systems Society (HIMSS) at:
http://www.himss.org/himss-nbin/loadframes?/side.nav.html?exhibits|/industry/sed/index.html

Another online directory of health information system vendors is available from the Health Management Technology Resource Guide 2000 at:
http://www.healthmgttech.com/

An overview of healthcare information standards is available from the Computer-based Patient Record Institute (CPRI) at:
http://www.cpri.org/resource/docs/overview.html

"Implementing the CPR: A Journey" by Art Frohwerk is available online from the American Health Information Management Association (AHIMA) at:
http://www.ahima.org/journal/features/feature.9903.2.html

Federal government's HIPAA (Health Insurance Portability and Accountability Act) Administrative Simplification website at:
http://aspe.os.dhhs.gov/admnsimp/

Agency for Healthcare Research and Quality (AHRQ) Home Page at:
http://www.ahrq.gov/

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* The resources and Internet sites indicated herein have been selected to aid the reader in starting to find useful background information. This should not be construed to be a complete listing of resources. The American Hospital Association (AHA) does not endorse or seek to promote the systems described by those entities listed here, or make any representations or warranties of any nature whatsoever about them, including any regarding the utility, accuracy, or fitness for a particular purpose of these systems. AHA is not a representative of these entities and is not authorized to make representations on their behalf. Additional information may be secured directly from the vendors and organizations listed.

Health Level-7 Standards Home Page at:
http://www.hl7.org/

Glossary

Active clinical decision support: a system feature designed to aid directly the physician in the clinical decision-making process by generating patient-specific assessments or recommendations through the integration of known characteristics of individual patients with computerized knowledge bases and pre-programmed clinical rules.

Alert: system feature that notifies the caregiver when a value is out of normal range or a drug interaction is likely.

Artificial intelligence systems: software that couples pattern recognition and reasoning with known medical knowledge in an attempt to replicate the actual decision-making of an expert physician.

Automated medication-dispensing system for nurses: device for controlling and monitoring the decentralized dispensing of medications, often using a system of restricted-access drawers. Requires user to enter a personal identification number for access. Some use software to tie the transaction to a patient profile. Some prompt nurses when medications are due. May be linked to bar coding devices and/or hospital information systems.

Bandwidth: the data-carrying capacity of the connectors linking workstations and other remote components of a computer network.

Care management support: by aggregating multiple encounters and multiple clinical records into a data "warehouse," retrospective analysis is possible to guide process improvement efforts.

Computer-based patient record: electronic medical record built in part through capture of order entry and residing in a system specifically designed to support users through availability of complete and accurate data, practitioner reminders and alerts, clinical decision support, links to bodies of medical knowledge, integrated communications support and other aids.

Computerized physician order-entry (POE): direct entry of one or more types of medical orders by a physician into a system that transmits those orders electronically to the appropriate department. Often coupled with online results reporting and active clinical decision support.

Critiquing: system feature that automatically provides diagnostic or therapeutic suggestions at the time an order is written, based on expert clinical rules incorporated into the software program.

Data input device: any device to enter data into a computer, e.g., keyboard, mouse pointing device, light pen pointing device, touchscreen monitor, voice recognition software, and/or interface with personal data assistants (PDAs).

Electronic medical record (EMR): capture and storage of patient medical record in computer-readable electronic format.

Health Insurance Portability and Accountability Act (HIPAA): Federal law governing standards for privacy of individually identifiable health information, national provider identifier, transactions and code sets, employer identifier, and security and electronic signatures. The U.S. Department of Health and Human Services developed standards pursuant to this law.

Health Level-7 Standards (HL7): Health Level-7 is one of several American National Standards Institute (ANSI)-accredited Standards Developing Organizations (SDOs) operating in the healthcare arena, that develops specifications, the most widely used being a messaging standard that enables disparate healthcare applications to exchange key sets of clinical and administrative data.

Meta-analysis: statistical technique for combining the results of published studies to enable a more powerful assessment of the net findings of all studies within a category of interest.

Passive decision support: a system feature that simply presents reference material or organized clinical data about a patient to the caregiver – no "intelligent" processing of that information takes place.

Personal data assistants (PDAs): small, battery-operated, handheld computers ("organizers") usually capable of synchronizing with a personal or network computer system.

Pharmacy information system: computer database used by pharmacists and pharmacy technicians to input medication orders. Used for inventory control and billing purposes. Features often include checking for inappropriate dose range, drug-drug interaction, and drug allergy. May also generate labels and patient information sheets.

Reminder: system feature that notifies the caregiver when an intervention is overdue.

Rule: expert clinical decision criteria incorporated into a software program such that the program is able to critique orders and generate reminders using known patient information and a medical knowledge base.

Screen turnover rate: speed (in seconds) required for one data entry or retrieval screen to be replaced by the next logical screen. Speed is a function of processing power, bandwidth, instruction complexity, and system user load.

Warehouse: hardware and software locus of encounter data from multiple departments on a system, or integrated from multiple separate but linked systems, where information is stored in such a manner so as to facilitate analysis of those aggregated data.

Web-based software: processing software that is located on a distant system and interfaced using Internet browser software on the user's workstation and network connectivity.

Workstation: networked personal computer, or other interface with the system, to allow input and retrieval of information.

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Figure 1. Computerized Physician Order-Entry Systems: Investment Decision Flowchart