

# Computerized Physician Order Entry: A Look at the Vendor Marketplace and Getting Started

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**The Leapfrog Group** is promoting three patient safety practices as the initial focus for consumer education and information and hospital recognition and reward. One of these is the use of computerized physician order entry (CPOE) in hospitals to prevent serious medication errors.

**First Consulting Group (FCG)** has developed the methodology to help hospitals evaluate whether their CPOE systems meet the Leapfrog standard. (For more information, consult the companion report, *Overview of the Leapfrog Group Evaluation Tool for Computerized Physician Order Entry*.) The project has been funded through a grant from the California HealthCare Foundation's Quality Initiative directly to FCG and through a Robert Wood Johnson Foundation grant to the Academy for Health Services, host organization to The Leapfrog Group.

At the request of The Leapfrog Group and the foundations that funded the project, this report shares additional information gathered during the project. Many hospitals are headed down the path toward implementing CPOE. It is hoped that current information about the vendor marketplace and important considerations in organizing and starting the CPOE effort will aid them as they do so. The report was prepared by Jane Metzger and Fran Turisco of First Consulting Group. They are grateful to key staff of the vendor organizations named in the report for accommodating an accelerated timeline for product demonstrations and repeated telephone calls.

**The Leapfrog Group** is a growing consortium of more than 90 Fortune 500 companies and other large public and private health care sector purchasers working to mobilize employer purchasing power to improve the safety and overall value of health care. It was founded by the Business Roundtable, a national association of Fortune 500 CEOs. The Leapfrog Group received additional support from the National Health Care Purchasing Institution. More information can be found at [www.leapfroggroup.org](http://www.leapfroggroup.org).

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This report can be found on the following web sites: [www.leapfroggroup.org](http://www.leapfroggroup.org) and [www.fcg.com](http://www.fcg.com)

## Executive Summary

A big agenda item for most hospitals in the U.S. is implementing computerized physician order entry (CPOE) for inpatients. This stems from the endorsement of CPOE in the 1999 Institute of Medicine report *To Err is Human*, subsequently reinforced by industry responses such as The Leapfrog Group CPOE standard and Senate Bill 1875 in California, which calls for a medication error reduction strategy in hospitals that includes the use of technology such as CPOE. A very small percentage of hospitals in the U.S. have CPOE in place. This means that most are looking at the options for adding or enhancing clinical systems supporting inpatient care and successfully implementing tools such as CPOE.

This report provides a starter set of information for decision-makers in hospitals to help them organize their CPOE effort and launch the search for an appropriate CPOE solution. It is meant to serve as background reading rather than a comprehensive information resource. Sources of information include vendor demonstrations, conversations with vendor CPOE project managers, and prior knowledge and experience of First Consulting Group (FCG). For a number of vendors, the FCG team also verified information during the pilot of the evaluation methodology for the Leapfrog CPOE standard. Discussion of vendor products should not be interpreted as an endorsement of any particular CPOE system.

### **What software products are available today to hospitals in the U.S.?**

As of August 2001, 13 CPOE vendor products are on the market. Eight are being actively marketed *and* used in a hospital beyond the pilot stage in one nursing unit. The other five are set to emerge in the coming weeks and months. All of the emerging products are in an advanced state of development, and vendors have already identified initial implementation sites. Vendors in the CPOE marketplace are both traditional vendors of hospital information systems, with names very familiar to the industry, and vendors new to inpatient clinical systems or to the market altogether. Purchasers today have many more options than they did even 12-18 months ago.

### **What clinical decision support tools does CPOE offer and what contributions can these make to electronic ordering?**

Clinical decision support (CDS) includes any tool within the CPOE application that provides guidance and/or incorporates knowledge to assist the physician in entering complete, accurate, and appropriate patient care orders. It also includes alerts that notify physicians when they need to reconsider orders based on new information about a patient's condition. Nine categories of CDS tools have been identified. These range from very basic tools such as order templates that include required fields and limit entries to allowable values and order sets (groups of orders, an electronic version of standing orders) to tools that apply logic to a combination of information in the order, information about the patient, and knowledge about clinical practice. Each tool can contribute to improved ordering in slightly different ways. Together they represent a powerful toolset for the hospital to implement.

### **What clinical decision support features do CPOE vendor products currently offer?**

Today's CPOE products contain a rich CDS toolset:

- Most of the eight currently available products have at least basic support for each category of CDS; six have comprehensive tools in 6-9 categories.
- The five emerging products also have, or will soon have, very comprehensive CDS.

All of the CPOE products are works in progress. Vendors are very aware of the need and potential for clinical decision support. They continue to pour enormous resources into further

development, and many have already defined additional CDS features for release over the next 12-18 months.

### **What else is involved in selecting a CPOE solution and positioning the hospital for success?**

Choosing the right CPOE solution for the hospital requires thinking about many features beyond CDS, and many tradeoffs involving implementation, technology, cost, and risk. In the end, the organizational challenges are greater than the technology challenges. Thus, the task of selecting the CPOE solution—though necessary—is only the beginning. Success requires a deliberate strategy, leadership commitment and involvement, an organized project structure to get the work done, extraordinary efforts by clinicians to master and integrate new tools into their routine, and considerable investment of resources in IT and change management.

# Chapter 1

## Introduction

### Background

Since the publication of *To Err is Human* by the Institute of Medicine [1], hospitals in the U.S. have been focusing more attention on patient safety—in particular, medication-related safety in the hospital. Computerized physician order entry (CPOE) is one technology-enabled intervention recommended by the IOM as a proven method to decrease medication-related errors and adverse events in hospital patients.

“Prevention requires the continuous redesign and implementation of safe systems to make errors increasingly unlikely, for example, using order entry systems that provide real-time alerts if a medication order is out of range for weight or age or is contraindicated.” IOM Report [1]

Consequently, many hospitals have been considering an investment in CPOE or are accelerating their plans to implement electronic ordering. For hospitals in California and the seven pilot regions of The Leapfrog Group, government and employer actions have increased the impetus to implement CPOE:

California Senate Bill 1875 requires health facilities and clinics (including general acute care hospitals, specialty hospitals, and surgical clinics, but excluding small and rural hospitals) to implement a formal plan to eliminate or substantially reduce medication-related errors by 2005. “This plan shall include technology implementation, such as, but not limited to, computerized physician order entry or other technology that, based upon independent, expert scientific advice and data, has been shown effective in eliminating or substantially reducing medication-related errors.” ([www.leginfo.ca.gov/bilinfo](http://www.leginfo.ca.gov/bilinfo))

The CPOE standard of The Leapfrog Group, a consortium of health benefits purchasers: “Hospitals that report adoption of this standard will: (1) require physicians to enter medication orders via computer linked to prescribing error prevention software; (2) demonstrate that their CPOE system can intercept at least 50% of common serious prescribing errors, utilizing test cases and a testing protocol specified by Leapfrog; (3) require documented acknowledgment by the prescribing physician of the interception prior to any override; and (4) post the test case interception rate on a Leapfrog-designated web site.” ([www.leapfroggroup.org](http://www.leapfroggroup.org))

A very small percentage of hospitals in the U.S. have computerized physician order entry in place. Some of those that do never achieved widespread physician participation and/or implemented early CPOE products with limited ability to assist physicians in avoiding errors. This means that most U.S. hospitals are considering enhancing or adding to the clinical systems supporting inpatient care and implementing tools such as CPOE successfully.

## What is CPOE?

CPOE is a clinical software application designed specifically for use by physicians to write patient orders electronically rather than on paper. The current industry focus is on *inpatient* CPOE, and the term generally refers to electronic ordering for hospitalized patients.

CPOE solutions for the hospital have evolved considerably. CPOE applications today are electronic portals supporting physician messaging, results management, patient rounding, and access to knowledge tools, in addition to the specific task of writing orders. For order entry, a CPOE application is designed to help the physician by making available relevant patient information as he/she writes orders and by providing prompts and alerts based on rules-based logic. The clinical decision support (CDS) tools of the CPOE application make this real-time assistance possible; each hospital activates, customizes, and adds to the tools that are available to ensure fit with local practice and patient safety and quality initiatives. In operation, the CPOE application is linked with other applications and databases that provide the needed patient information and facilitate delivery of the ordered interventions, such as admitting, nursing, and pharmacy systems, applications for other ancillary services, etc.

## What CPOE is *not*?

Most hospitals in the U.S. have an application designed for non-physicians (often nurses, ward clerks, and/or pharmacists) to enter orders electronically from the physician's written orders in the patient chart. This application is for *order communication*, rather than CPOE. The distinction is important because order communication involves a different process and user, does not treat orders the way a physician thinks about them, and, with the exception of some pharmacy systems, includes little if any decision support for improving ordering. The fact that the names of many vendor order communication products include the term "Order Entry" adds to the challenge of understanding what process applications actually support.

## Purpose and Organization of This Report

This report provides a starter set of information for decision-makers in hospitals to help them organize their CPOE effort and launch the search for an appropriate CPOE solution. Sources of information include vendor demonstrations and conversations with vendor CPOE project managers, combined with the prior knowledge and experience of First Consulting Group (FCG). For a number of vendors, the FCG team also verified information during the pilot of the evaluation methodology for the Leapfrog CPOE standard.

Based on the information gathered, this report provides basic information to answer four questions:

1. What software products are available today to hospitals in the U.S.? (Chapter 2)
2. What clinical decision support tools does CPOE offer and what contributions can these make to electronic ordering? (Chapter 3)
3. What decision support features do CPOE vendor products currently offer? (Chapter 4)
4. What else is involved in selecting a CPOE solution and positioning the hospital for success? (Chapter 5)

Most of the potential benefits of CPOE do not come from merely replacing paper orders with electronic ones. Rather, during a physician's decision-making process about what to order and how to order it, the computer applies edits, displays relevant information and advisory prompts to help the physician enter orders correctly and make optimal ordering decisions. All of this support to physician ordering is delivered by the CDS tools in the product and how the hospital sets up and maintains them. Much of this report is devoted to understanding CDS tools, how they work, and what they can contribute because this is an important first step in evaluating vendor solutions and preparing for implementation.

This report is a primer for decision-makers in hospitals who will be involved in the CPOE effort, not a comprehensive information resource. The information provided is meant to aid hospitals by providing useful background reading about the vendor marketplace and some of the factors to be including in their evaluation. Reading this primer is not a substitute for a rigorous vendor selection process.

Staff from the Information Systems (IS) Department are always involved in evaluating computer applications. However, coming up with the right IS solution for CPOE *must* involve physicians and many others in the hospital with less information technology vocabulary and experience. Geared to the latter group, this primer avoids both jargon and highly technical detail.

The vendor marketplace is a moving target. During the study that led to this report, three new vendors of CPOE solutions emerged. In addition, every vendor is making substantial investments in enhancements to the CPOE solution in their application portfolio. The information in this report was gathered during June-August 2001. Discussion of vendor products should not be interpreted as an endorsement of any particular CPOE system.

## Chapter 2 CPOE Products

As of August 2001, 13 CPOE vendor products are on the market in the U.S. They fall into two groups in terms of product availability:

- Eight products are already being actively marketed *and* used in at least one hospital beyond the pilot phase and in at least two patient care units.
- The other five products are in various stages of final testing, piloting, and market release. Most are being actively marketed, and all are expected to emerge later this year or early next year.

Table 1 lists the eight products currently available and provides basic information about product history. Since every product is a work in progress, the version number of the product reviewed in subsequent tables in this report has been listed. (Note that products in use but no longer available for purchase have not been listed.)

**Table 1. CPOE Software Applications Available in August 2001\***

Product	Vendor	First Implementation Date	Number of Hospitals Installed		Selected Implemented Sites	Scheduled Implementations within the next nine months
			CPOE with Meds	CPOE without Meds		
Millennium Health Network Architecture (HNA) (CUM version Jan 01)	Cerner	1997	2		<ul style="list-style-type: none"> <li>• A.I. Dupont</li> <li>• University of Illinois Chicago</li> </ul>	9 sites in progress
CliniComp Computerized Physician Order Entry	CliniComp	2000	1		<ul style="list-style-type: none"> <li>• Walter Reed Army Medical Center</li> </ul>	3 sites in progress
Sunrise Clinical Manager (Version 3.01)	Eclipsys	1998	13		<ul style="list-style-type: none"> <li>• Children's Hospital of Milwaukee</li> <li>• Alamanse Hospital</li> <li>• Sarasota Memorial Hospital</li> <li>• Boston Medical Center</li> </ul>	8 sites in progress
LastWord Enterprise Clinical System (Version 4.1)	IDX	1999	2	1	<ul style="list-style-type: none"> <li>• Montefiore Medical Center</li> <li>• Stanford University Medical Center</li> </ul>	4 sites in progress
Client Server (Version 5.2) and Magic (4.8) product lines	Meditech	1999	5	2	<ul style="list-style-type: none"> <li>• Deborah Heart and Lung</li> <li>• Chicago Rehabilitation Hospital</li> </ul>	17 sites in progress
Patient 1 (Version 2)	Per Se	2000	4		<ul style="list-style-type: none"> <li>• Princeton Medical Center</li> <li>• Jacobi Medical Center</li> </ul>	5 sites in progress

Product	Vendor	First Implementation Date	Number of Hospitals Installed		Selected Implemented Sites	Scheduled Implementations within the next nine months
			CPOE with Meds	CPOE without Meds		
Invision (24.0 with Web browser)	Siemens SMS	1995	8		<ul style="list-style-type: none"> <li>Ohio State University Medical Center</li> <li>University of Texas Medical Branch</li> <li>Meridian Health System</li> <li>Neptune NJ Medical Center</li> <li>Kingsbrook Jewish Medical Center in Brooklyn</li> </ul>	10 sites in progress
VisualMD	VisualMED	2001	1		<ul style="list-style-type: none"> <li>St Justine – Canada</li> <li>Montreal Heart Institute (beta, not in production)</li> <li>Royal Victoria (development site)</li> </ul>	2 sites in progress

\*Available and in use in one hospital in at least two inpatient units.  
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Five other vendors are poised to bring CPOE products to market in the coming weeks and months. Basic information about these products is provided in Table 2.

**Table 2. Emerging CPOE Products**

Product	Vendor	Expected Release Date
Care Innovation (Version 8.0)	3M	Winter 2001 for beta site
Point of Care (POC) (Version 3.5)	Autros	August 2001 for beta site
EpicCare Inpatient Clinical System (Version 1.0)	Epic	Fall 2001 for beta site
Horizon Clinicals	McKesson	End of 2001 for beta site
Centricity	GE Medical Systems	Fourth Quarter 2001 for more complete rollout in beta site

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### Why are so many of the products so new?

Traditional vendors of hospital information systems—with names very familiar to the industry—have rewritten older applications for CPOE using new technology and incorporating today’s definition of more comprehensive clinical decision support. They have been joined in the marketplace by vendors new to inpatient clinical systems or to the market altogether. Purchasers today have many more options than even 12-18 months ago!

### **In Table 1, why the distinction between CPOE with and without medications in the information about installed hospitals?**

The Leapfrog CPOE standard targets primarily medication orders. Table 1 reports product use for two groups of hospitals: those using the product for physician entry of all orders (including medications) and those where physicians do not yet order medications electronically. Some hospitals start with a subset of orders rather than full CPOE. Because medication orders are the most difficult to enter electronically and the medication management process is so complex, some hospitals have physicians initially enter all other types of orders, adding medications once physicians have become accustomed to electronic ordering and all of the details concerning medication management have been worked out. Getting an accurate picture of the extent of industry experience with the product with respect to medication ordering—and vendor experience with implementation—requires making this distinction.

### **How quickly is the industry gaining experience with CPOE?**

The number of hospitals using *currently available* CPOE products is very small, but the U.S. hospital industry is clearly at the beginning of a very rapid learning curve. Table 1 lists implementations already scheduled and with active preparation underway that should lead to operational CPOE sites within the next 6-9 months. (Note that these figures do not include either self-developed CPOE systems or older products no longer available for purchase.) In addition, each of the five vendors of emerging products has already identified multiple initial hospital sites, which will soon be up and running with CPOE. (These were not counted because of uncertainties about product release dates and implementation schedules.) The bottom line is that vendor and hospital experience with implementing today's CPOE products will probably triple in the next year.

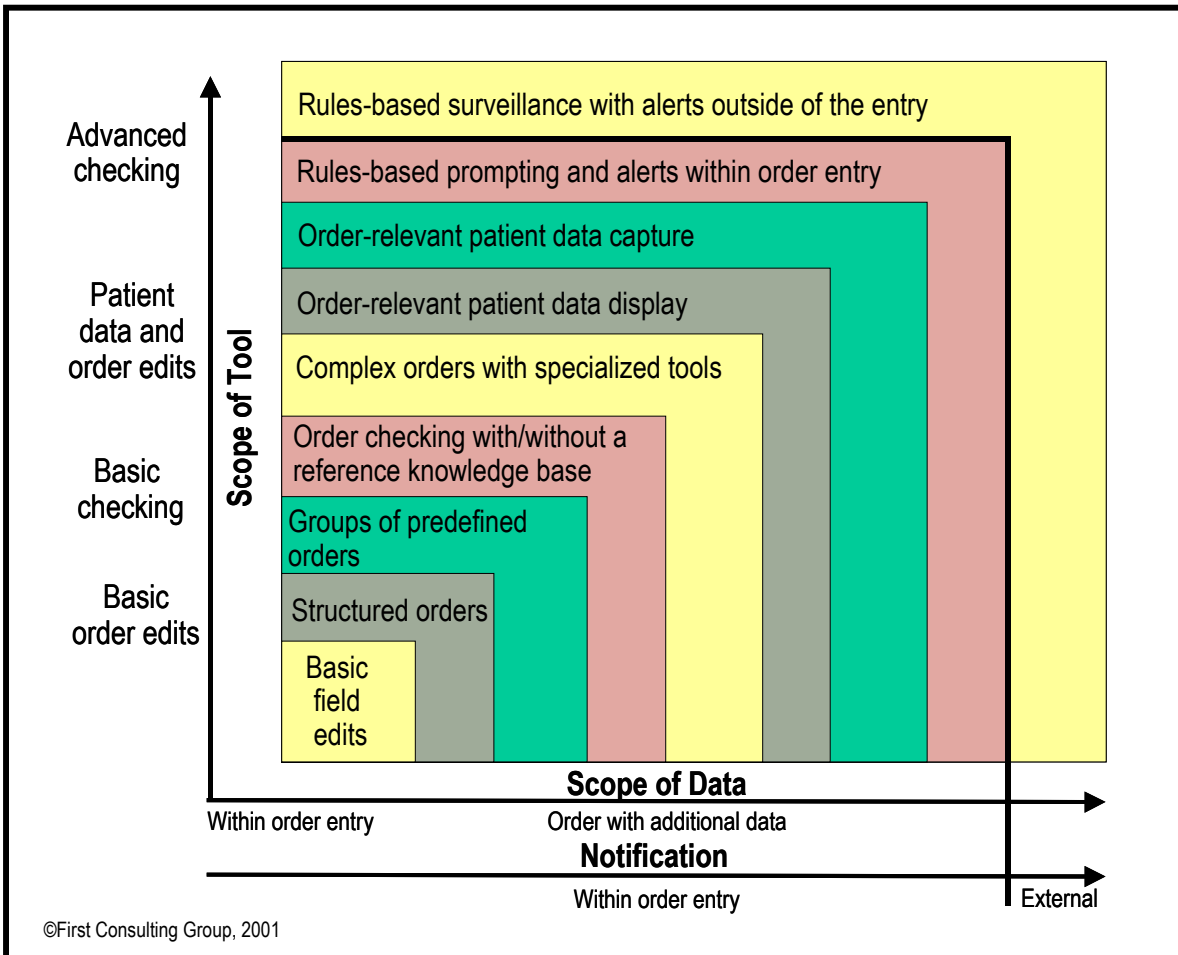
## Chapter 3 Introduction to CPOE Clinical Decision Support

Many different features of a CPOE application contribute to better ordering and decision-making about orders. Some of the more basic ones, such as field edits and data entry templates, are found in many applications used in the hospital, but others are quite unique to this application and the process it supports.

Clinical Decision Support (CDS) includes any functionality within the application that provides guidance and/or incorporates knowledge to assist the clinician in entering complete, accurate and appropriate patient care orders. This definition covers a broad range of CDS tools, which can be categorized based on two inter-related characteristics: the scope of the data employed by the tool, and the complexity of the logic that can be applied to the available data.

The specific CDS features of CPOE were identified from prior work on clinical decision support [3], previous contacts and conversations with a number of CPOE pioneers (including all of the winners of the Nicholas Davies Award), and an understanding of the products in the marketplace. Additions and refinements to the list continued during the review of CPOE vendors. All of the identified features were organized into the nine categories shown in Figure 1.

**Figure 1. Categories of Clinical Decision Support  
Related to Computerized Physician Order Entry**



As the scope of the data expands from what is contained within an individual order to information about the patient and from outside knowledge bases, the logic of CDS tools can take more into consideration. For example:

- Using the data in an individual order (e.g. medication, route of administration, dose, frequency, date), basic order edits and templates make available default values, predefined selection lists, and required fields that guide the user in entering the order accurately and completely. By constraining the possible field entries (e.g., only the appropriate routes of administration for a particular medication), these tools can also aid in avoiding errors.
- When patient-specific information on laboratory results, patient age, and weight and medication-related reference knowledge are all added to the mix of available information, CDS tools can take all of these factors into account when checking for appropriate dosing of a medication being ordered. When the current medication order can be evaluated alongside other active medication orders and medication reference knowledge, checking for therapeutic overlaps and drug-drug interactions becomes possible.
- At the upper end of the spectrum of CDS tools in Figure 1 is surveillance for changes in patient condition with physician alerting to reconsider a particular order. Surveillance links up orders and new information about patient renal function or newly reported information about patient vital signs, extending the application of logic to times between physician ordering sessions. Although real-time surveillance with physician notification can be accomplished without having CPOE in place, the necessary software and communication tools are usually bundled with a CPOE application.

Table 3 describes each category of CDS, along with the potential contribution to patient safety and quality. (Detailed functions and features defined for each category are listed in Appendix A.)

**Table 3. Description of Clinical Decision Support Categories**

Category of Clinical Decision Support	Description	Contributions to Safety/Quality
<b>Basic field edits</b>	Setting of basic parameters for contents entered into individual fields including numeric/text, decimal format, required fields; used to edit information entered such as dosage amounts	<ul style="list-style-type: none"> <li>• Reduced errors due to grossly erroneous information in order fields</li> </ul>
<b>Structured orders</b>	Templates for each ordered service that specify data fields to be completed and guide choices with allowable values, defaults, and required fields	<ul style="list-style-type: none"> <li>• More complete, actionable orders</li> <li>• Reduced errors of omission or commission through field entry appropriate to the type of intervention being ordered (route of administration) and local practice (dosage dispensed in pharmacy, timing of routine blood draws)</li> </ul>
<b>Groups of predefined orders</b>	Pre-defined grouping of orders that can be selected by user as a starting point for patient-specific orders (order set, clinical pathway) or is displayed automatically (corollary order) whenever linked service is being ordered (e.g., a medication order that should be accompanied by an order to test blood levels of the medication to titrate dosing)	<ul style="list-style-type: none"> <li>• Reduced errors due to incomplete or erroneous information through use of sets of pre-structured orders with appropriate fields and field contents for each type of intervention being ordered and local practice</li> <li>• Increased compliance with recommended care for particular diagnosis, procedure, and/or phase of management (admission, post-op for a given diagnosis or procedure)</li> </ul>

Category of Clinical Decision Support	Description	Contributions to Safety/Quality
<b>Order checking (with or without a reference database)</b>	Checking of medication orders for drug interactions and contraindications (e.g., drug-drug and drug-allergy checking, min-max dose ranges, duplicate and therapeutic overlap checking.) For medications, likely to include the use of an industry reference database. Also checking of non-medication orders to duplicates within specified timeframes.	<ul style="list-style-type: none"> <li>• Reduced errors due to flagging of potential contraindications</li> <li>• Improved quality due to facilitated access to reference information on medications</li> <li>• Reduced ordering of unnecessary duplicate interventions</li> </ul>
<b>Complex orders with specialized tools</b>	Templates and tools such as dose calculators to guide entry of orders with complex dosing or administration requirements (e.g., taper dosing, sliding scale, alternate day dosing, custom TPN, chemotherapy).	<ul style="list-style-type: none"> <li>• Reduced errors of omission and commission in complex orders</li> <li>• More accurate dosing calculations</li> <li>• Ability to capture broader range of patient orders with CPOE and include them in checking for contraindications</li> </ul>
<b>Order-relevant patient data display</b>	Automatic display of patient information relevant to the intervention being ordered (typically laboratory data to be reviewed before ordering a medication)	<ul style="list-style-type: none"> <li>• Facilitated review of patient information that might influence choice, timing, or dose of medication or other intervention</li> </ul>
<b>Order-relevant patient data capture</b>	Prompting to verify and/or supply patient-specific information not included in orders, but needed to screen intervention for possible contraindications (e.g., allergy) or to perform necessary calculations (patient weight, body surface area); also includes prompting about clinical appropriateness with documentation of relevant clinical indications	<ul style="list-style-type: none"> <li>• Expanded availability of relevant patient information for decision support (can serve as additional Q/A check on data routinely captured or supply information not captured electronically)</li> <li>• More appropriate use of targeted interventions and capture of relevant information for subsequent review or analysis of clinical appropriateness</li> </ul>
<b>Rules-based prompting and alerts within order entry</b>	Real-time prompting and alerting at the time of order entry, based on explicit rules and a range of patient-specific electronic information. Includes patient-specific dosing (calculator, suggested dose, and/or dosage checking).	<ul style="list-style-type: none"> <li>• Reduced errors of omission and commission in ordering</li> </ul>
<b>Rules-based surveillance with alerts outside of order entry</b>	Prompting and alerting to reconsider ordered interventions based on new information regarding patient characteristics or status, with notification outside of electronic order entry	<ul style="list-style-type: none"> <li>• Reduced delays in re-evaluating patient management strategy based on new information about the patient</li> </ul>

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### ***Which categories of CDS are most important?***

One of the misconceptions in the industry is that a “rules engine” is the major decision support tool in a CPOE application. In fact, today’s CPOE products allow hospitals to set up many kinds of rules-based decision support. Screen edits that check for reasonable and allowable field contents, pull-down lists that define choices, order templates that specify required fields, and order sets all provide very useful CDS tools that can be implemented relatively easily. In addition, every CPOE product uses knowledge from third-party medication reference tools and does not require rule writing to implement prompts and alerts based on that knowledge. Many products offer the ability to implement additional prompts and displays by setting up the parameters in order master files. A rules engine does permit introducing CDS not available through other mechanisms, and ideally the hospital has one as part of the CDS toolset. However, hospitals can begin to make significant improvements in patient safety and quality without a rules engine.

### ***Which categories of CDS are most important for meeting the Leapfrog CPOE standard?***

The Leapfrog Group has identified three initial patient safety standards as the focus for consumer education and information and hospital recognition and reward: Computerized Physician Order Entry (CPOE), ICU Physician Staffing, and Evidence-based Hospital Referral. The intent of the CPOE standard is to encourage use of CPOE with clinical decision support that can intercept dangerous orders. Specifically it requires that physicians enter orders electronically and that the system be able to intercept at least 50 percent of common serious prescribing errors. To demonstrate that the CPOE implementation meets the standard, hospitals will enter a pre-defined set of orders that contain such errors and record the system response. (For more information about the evaluation methodology, refer to [2].)

The evaluation tool for the Leapfrog CPOE Standard includes 12 categories of orders. Table 4 maps these to the types of clinical decision support that can help to avoid the errors contained in the orders. As shown, many types of CDS can aid in avoiding errors and adverse events of the types being evaluated. (The scoring methodology developed for the CPOE evaluation takes multiple types of CDS into account.) Thus there is no neat CDS roadmap for success. Rather the hospital needs first to define the patient safety and quality issues to be addressed (order categories in the Leapfrog CPOE standard are one good starting point) and then make good use of all of the CDS tools available to address those issues. When the complete toolset *is not* available, implementers should make full use of what they have. Even some of the more basic tools permit progress.

### ***Which CDS tools do hospitals use first? Which ones the most?***

The job of employing CDS is new and the task is large. Setting up the necessary governance, committee structure, and process takes time, and those in charge for the hospital understandably proceed with caution. According to vendors, some hospitals focus first on implementing CPOE, a large task on its own, first making use of order sets and some of the simpler forms of CDS that can be set up fairly easily. Once physicians are accustomed to electronic ordering, they progress to more complex forms of CDS, including writing new rules for alerts and prompting.

**Table 4. Mapping of Order Categories in Evaluation Tool for Leapfrog CPOE Standard to Clinical Decision Support**

CDS Tools/Order Categories	Order Edits/ Structured Orders	Groups of Pre-defined Orders	Order Checking with/without Reference Knowledge base	Complex Orders with Specialized Tools	Order-Relevant Patient Data Display	Order-Specific Data Capture	Rules –Based Alerts within Order Entry	Rules–Based Surveillance with Alerts Outside of Order Entry
Therapeutic duplication			✓				✓	
Single and cumulative dose limits	✓		✓	✓				
Allergies and cross-allergies			✓			✓		✓
Contraindicated route of administration	✓	✓	✓	✓				
Drug-drug and drug-food interactions			✓				✓	
Contraindication/dose limits based on patient diagnosis		✓	✓			✓	✓	
Contraindication/dose limits based on age and weight			✓	✓		✓	✓	
Contraindication/dose limits based on laboratory studies			✓	✓	✓		✓	✓
Contraindication/dose limits based on radiology studies			✓				✓	
Corollary		✓					✓	
Cost of care	✓		✓			✓	✓	
Nuisance			✓				✓	

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## Chapter 4

### Clinical Decision Support Tools in CPOE Products

The CDS tools are clearly one important area of product capabilities to be considering when comparing possible CPOE solutions. The following discussion summarizes what CDS toolset current products offer hospitals. Making a distinction between product features and their application is important because off-the-shelf products don't provide clinical decision support. Rather the implementing hospital sets up and manages the available CDS tools to deliver clinical decision support.

Tables 5 and 6 summarize the CDS tools in the CPOE products identified previously (Tables 1 and 2) as of August 2001. A distinction has been made between basic tools in each category of CDS that apply to a broad spectrum of orders and those that are more complex or apply to highly specialized orders. (Refer to Table A-1 for further details concerning basic and advanced tools.)

As can be seen, today's CPOE products (and related clinical applications) contain a rich toolset for a hospital to use in improving patient safety and quality. This situation has improved dramatically in the last year or two.

- Most of the currently available products have at least basic functions for each category; six have comprehensive support in 6 to 9 categories.
- Of the emerging products, three have very comprehensive CDS, while another is expected to be at an earlier stage of development in the initial release. As noted in Table 6, one of the emerging products has not been assessed in detail because the vendor partnered very recently with a hospital with a locally developed CPOE application and the product is being rewritten before it is released.

CPOE products are all works in progress. Vendors continue to pour enormous resources into further development, and most have already defined new CDS features to be developed in increments over the next 12-18 months. During discussions as products were being reviewed, it appeared that vendors by and large are aware of current gaps in clinical decision support and intend to address them soon.

Table 5. Clinical Decision Support in Currently Available CPOE Products (August 2001)

Product	Vendor	Basic Field	Structured Orders	Groups of Pre-Defined Orders	Order checking with/without a Reference Database	Complex Orders	Order-Relevant Patient Data	Order Relevant Patient Data Capture	Rules-based Prompting and Alerts within Order Entry	Rules-based Surveillance with Alerts Outside of Order Entry
HNA (CUM Version January 2001)	Cerner	✓+	✓	✓+	✓	✓	✓+	✓+		✓
CliniComp Computerized Physician Order Entry (Version 1.0)	CliniComp	✓+	✓+	✓	✓	✓		✓		
Sunrise Clinical Manager (Version 3.01)	Eclipsys	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+
Last Word Enterprise Clinical System (Version 4.1)	IDX	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓
Magic (Version 4.8) Client Server (5.2)	Meditech	✓+	✓+	✓+	✓+	✓	✓+	✓+	✓	✓
Patient 1 (Version 2)	Per Se	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+
Invision (24.0 with Web Browser)	SMS	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓
VisualMED (VisualMD)	VisualMED	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+

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**Notes:**

- Blank Missing more than one basic function
- ✓ Includes basic functions for category
- ✓+ Includes basic and ≥ 50 percent of advanced functions for the category

**Table 6. Clinical Decision Support in Emerging CPOE Products (August 2001)**

Product	Vendor	Basic Field	Structured Orders	Groups of Pre-Defined Orders	Order checking with/without a Reference Database	Complex Orders	Order-Relevant Patient Data	Order Relevant Patient Data Capture	Rules-based Prompting and Alerts within Order Entry	Rules-based Surveillance with Alerts Outside of Order Entry
Autros Point of Care (Version 3.5)	Autros	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓+	✓
EpicCare Inpatient Clinical System	Epic	✓+	✓+	✓+	✓+	✓	✓+	✓+	✓+	✓+
Centricity 3.0	GE Medical Systems	✓+	✓+	✓+	✓+	✓	✓+	✓+	✓+	✓+
Care Innovation Physician Order Entry	3M	✓+	✓+	✓	✓				✓	✓
Horizon Clinicals Horizon Expert Orders	McKesson	*	*	*	*	*	*	*	*	*

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**Notes:**

Blank Missing more than one basic function

✓ Includes basic functions for category

✓+ Includes basic and ≥ 50 percent of advanced functions for the category

\*On July 22 McKesson announced a partnership with Vanderbilt University Medical Center to build a CPOE solution based on Vanderbilt's existing system. Because this will involve rewriting and reconfiguring before the software is released as a commercial product, specific capabilities are not reported.

### Points to consider when evaluating CDS capabilities

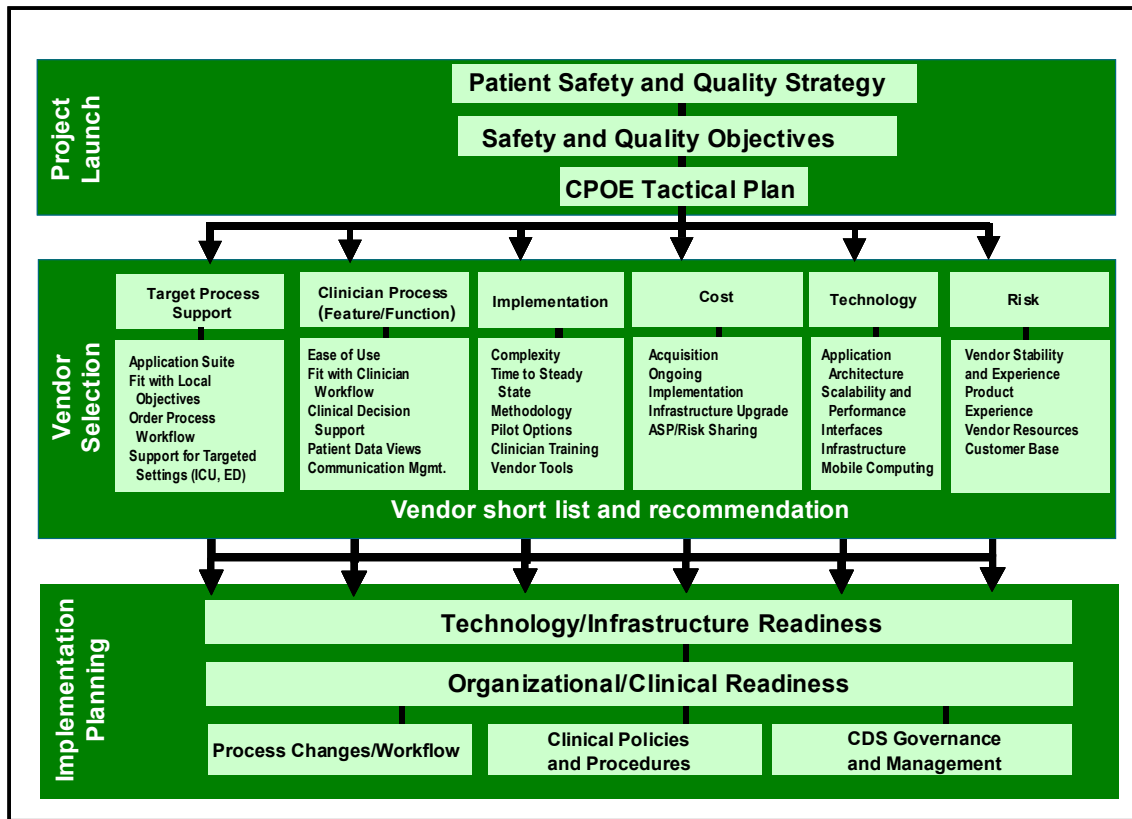
- The mix of CDS tools needed to meet the hospital's safety and quality objectives.
- Specific approaches available for addressing the order categories in the Leapfrog CPOE evaluation.
- Extent of use of third-party reference databases or other embedded knowledge in medication order checking. What level of control does the hospital have over alerting based on third-party data (set level of checking for all medications, set for individual medications)?
- How much flexibility the product offers the hospital to control the delivery of prompts and alerts to different types of physicians (medical students, residents) and to nurses and pharmacists.
- How much flexibility the product offers the hospital to control the way users must *respond* to an alert (can't proceed to complete order, proceed with reason noted, information only) so that CDS can be implemented consistent with the hospital's philosophy about directing versus guiding care.
- How the product design integrates alerts, prompts, and informational messages into the order workflow.
- The work required to implement each type of CDS. How much can be set up in order master files versus how much the hospital is required to write rules.
- The tools available in the product for managing CDS: audit trail and reports of exception documentation; version control and approach to testing CDS rules before general release.
- Availability of vendor CDS starter sets and knowledge bases or vendor support to sharing of CDS rules among customer hospitals.
- CDS features planned for the next release of CPOE by the vendor and planned within the next year. How does the R&D pipeline for the product (and related applications) fit with the hospital's safety and quality agenda?
- Success of current implementation sites with implementing CDS. How staff responsible for CPOE in current implementation sites rate the ease of setting up and managing CDS? How do they rate the availability of CDS tools to support the hospital's patient safety and quality goals?
- Number of hospitals that report that they meet the Leapfrog CPOE standard.

## Chapter 5 Other Important Considerations

So far this report has only addressed what CPOE products are on the market (or will emerge in the near future) and one critical set of functions—CDS tools. Clearly without the right CDS tools, the CPOE effort will be hampered. However, there are many other factors that go into selecting the right solution for the hospital.

In successful CPOE efforts, the task of selecting the CPOE solution is part of a much larger effort, as pictured in Figure 2. Some of the pre-requisite activities under “Project Launch” frame the needs of the hospital for a CPOE solution in significant ways, and it is important that the selection process incorporates these factors. Once hospital staff begin the process of evaluating vendor solutions, there are other functions and features to consider besides CDS, as well as tradeoffs between possible solutions according to process support, implementation, technology, cost, and risk. This final chapter briefly reviews these other factors, incorporating information gathered during the review of the vendor marketplace and from successful CPOE efforts to date.

**Figure 2. CPOE Vendor Selection within the Context of a Successful CPOE Project**



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### Project Launch

Like any software product, CPOE is just an electronic tool. How the tool is put to use is what makes the difference. In addition, the process CPOE supports – physician decision-making about

patient management – is the single most critical and complex one in health care. Success requires a deliberate strategy, leadership commitment and involvement, and an organized project structure to work through many phases and accomplish many tasks. It also requires extraordinary efforts by virtually every affected clinician to learn to incorporate CPOE into their work and considerable resource investment in both IT and change management. Even the most functional CPOE tool cannot deliver the desired changes without this organizational foundation, resources, and hard work by many in the hospital.

Since the IOM report was released, many hospitals have elevated and refocused their traditional quality improvement efforts. Some target patient safety by name, others medication management, or possibly more broadly, clinical quality improvement. A highly visible safety or quality initiative, combined with an improvement culture, provides the organizational underpinnings for success with CPOE. The hospital's agenda for patient safety/quality and the environment define the needs (and constraints) for CPOE and other clinical applications in very significant ways.

#### Points to consider before launching vendor selection

- The processes the hospital's patient safety/quality strategy is targeting. Is it primarily medication management? Where do other disciplines such as nursing and pharmacy fit in the vision of the ideal process?
- The safety and quality objectives guiding the hospital's efforts to improve these processes.
- Current gaps in information systems and technology infrastructure that stand in the way of creating the ideal process and realizing the safety and quality objectives of the hospital.
- The capacity of the hospital to consider CPOE solutions beyond those of the current HIS vendor and the related increased investment in process change and IT.
- The schedule for rollout of CPOE within the overall agenda for patient safety and quality.
- The resources committed by hospital executives and the board for IT and implementation.

### Vendor Selection

Selecting the appropriate CPOE application requires examining the factors discussed below. Final *decisions* require many tradeoffs between and among them.

### Process Support and Function/Feature

In addition to functions involving clinical decision support, selecting the right CPOE solution requires examining the scope of the CPOE-related applications and other functions of the application itself that facilitate physician acceptance and are supportive of the hospital's goals for improving care processes.

Ease of use and fit with clinician workflow are both somewhat inter-related and *sine qua non's* for success with CPOE. One of the single biggest challenges is replacing the pen and paper process with electronic data entry *without* increasing physician time. Doing so requires both making the order entry tasks as quick as possible and providing tools that can speed up other physician tasks such as locating patients, communicating with peers, managing diagnostic results, and gaining access to clinical knowledge. With electronic tools in place to help accomplish these other work

tasks efficiently and help physicians do a better job of taking care of their patients, most will accept that it takes slightly more time to write their orders.

Understandably, physicians want tools that support their workflow because it affects the value they receive from using the system, as well as the time it takes for them to accomplish system-supported tasks. Physician workflow differs when they are admitting a patient, doing rounds, or checking on patients from home or another remote location. It is also different for internal medicine specialists, obstetricians, and anesthesiologists and for those working in intensive care and general acute care. Fitting into all of these different work environments requires great flexibility in screen design and screen flow, as well as the ability for user customization. Supporting workflow also requires the ability to intersperse electronic tasks such as results review and order entry and to accommodate frequent interruptions. Physicians themselves are undoubtedly the best judges of ease of use and fit with workflow. By using scenario-based demonstrations and contacting peers in implementation sites, physicians can easily judge these important design features.

Many processes accept and manage physician orders and facilitate delivery of the ordered services, and the impact of the CPOE solution on related workflows needs to be examined. The hospital's patient safety and quality objectives often extend to the full medication management cycle or to nursing order completion. The processes targeted often expand the lists of functions to be assessed and the composition of the review team.

All advanced clinical applications vastly expand the scope of patient information available electronically and the potential access points and users. An appropriate CPOE solution must include the security tools and safeguards consistent with the hospital's security policies and procedures.

#### **Points to consider in evaluating CPOE process support and functions/features**

- Support for the different workflows in critical care, acute care, and emergency care settings targeted for CPOE.
- Design of support for complex medication orders such as sliding scale, customized IV's and titrations and for conditional orders.
- How medication orders are managed for downstream processes in the pharmacy and on nursing units.
- Integration with an electronic medication administration record (MAR) and related workflow for nurses and other clinicians.
- Display tools such as annotated patient rosters that help the physician quickly grasp outstanding work tasks (orders to sign, orders due to expire, results to review, messages) for relevant lists of patients (e.g., those admitted by the physician, patients for whom the physician is a consultant, other physician-maintained patient lists).
- In-box for organizing the management of new information and messages and ability for the hospital to customize notification procedures.
- Management of hand-offs and communications between medical students, residents, and staff physicians; between physicians, pharmacists, and nurses; and between admitting and consulting physicians.
- Management of patient transfers from one nursing unit to another (different level of care) and from one clinical service to another.
- Control of data access and order signature rights for types of users (medical students, staff physicians) and for types of orders with special requirements for review (e.g., oncology, research interventions).

## **Implementation**

CPOE implementations are not short projects. Hospitals need considerable advanced planning to accomplish and need to train a large number of staff. Furthermore, most implement CPOE first on one nursing unit or in one clinical department as a pilot for the redesigned procedures and the IT, as well as a dry run of the implementation approach. Only once all of the lessons from the pilot have been addressed, does further rollout begin. Specific implementation schedules for hospital-wide rollout are scaled to the scope of the applications and processes involved and the size and complexity of the hospital. CPOE vendors cite timeframes ranging from 9 months to 24 months, with an average of about 18 months a reasonable expectation for planning purposes.

The longer the implementation process, the longer the delay until the hospital can begin to reap the potential benefits of electronic ordering. Lengthy implementations that stall are also more costly. Most hospitals have a target timeframe for operationalizing CPOE. Thus, important considerations in understanding the differences among vendor options are the likely time to steady state and the factors that come into play. There are likely to be marked differences from one vendor to another and between using the incumbent HIS vendor for CPOE versus a new one. Staff at other hospitals who have already implemented CPOE are important sources of information about what is involved in implementation and how long it takes.

Many of the factors leading to a successful implementation are local, but there are some ways in which the vendor's approach to implementation can make a big difference. One is a vendor-supplied process and method for rollout. This provides a firm basis for planning, both for the hospital's efforts and those of the vendor and leads to a more predictable and coordinated rollout. Ideally, the methodology defines tasks, responsibilities, milestones, deliverables, and communications; includes a well-developed implementation work plan and staffing assignments; and can be built into the contract. Experienced implementers are scarce and may not be available in the local area. Pinning down vendor capabilities and resources as part of both vendor selection and implementation planning is another important step toward achieving the right mix of internal, vendor, and third-party staff needed to meet the hospital's timeline and budget for CPOE.

Clinician training is critical for smooth rollout and producing truly proficient users of CPOE. Ease of use is an important determinant of training requirements, as is the approach taken to training. Because training takes time away from work and is costly to provide, hospitals should consider vendor-supplied tools and services as part of decisionmaking about the right CPOE solution.

### **Points to consider in evaluating vendor implementation approach**

- Philosophy and recommended approach to rollout of CPOE and related applications. What methodologies and tools are available to assist hospitals?
- Implementation support services available from the vendor and from consulting firms providing implementation support.
- Time to hospital-wide rollout in hospitals of similar size and complexity.
- Reactions of project staff in other hospitals who have implemented the solution regarding the complexity, the challenges, and the performance of the vendor.
- Approach, tools, and services for training end users, as well as IS staff who will manage the application.
- Recommended approach and options for training physicians and nurses. How many hours of classroom training does the vendor recommend? What other methods are recommended? To what extent can the vendor support training with tools and services?

## **Technology**

There is no such thing as a stand-alone CPOE application. All of the CPOE products on the market come bundled with other clinical applications and databases because of the close inter-relationships between clinical processes and the applications that support them, as well as the need for standard data structures and vocabulary. Typically the bundled applications include a Clinical Data Repository (CDR), order communication, nursing medication administration, and a rules or alert engine (if not included with the CDR). Some vendors also market an integrated pharmacy application, which they recommend over interfaces to handle the critical and complex data exchanges between CPOE and pharmacy. All of this greatly complicates decisions about the appropriate CPOE solution.

Every hospital has applications such as Admission/Discharge/Transfer (ADT) and often order communication; some also have nursing and clinical documentation. The option of adding CPOE from the legacy vendor will, in some cases, require upgrades to the supporting applications. The option of switching to another vendor may involve swapping out or duplicating legacy applications, as well as accommodating a different technical architecture.

Products currently in the marketplace are either new – written for more open technical architecture – or ported to new technology. For purchasers this means that technical architecture is less of a differentiating factor than in the past. However, products differ in the role of the end user device in processing (thin versus thick clients), the allocation of processing within the server architecture, and use of relational and hierarchical databases. All of these factors need to be assessed in light of manageability and performance.

CPOE requires extremely reliable performance to avoid interruptions in key clinical processes and quick system response to each keystroke and screen change to meet physician needs. Both of these are absolute requirements for success with electronic physician ordering. Assessing these elements of performance requires looking at both the technical approach and the demonstrated performance in hospitals of similar size and complexity.

Physicians are highly mobile during their workday in the hospital, including when they are checking in on their hospitalized patients. Today's technology makes it easier to support mobile computing, and most CPOE vendors are moving toward full-function mobile computing. Because physicians will be demanding this mode of access, understanding current options for mobile computing and future plans is an important element of evaluating CPOE solutions.

Ultimately, the performance of the system in the clinical work environment is only as good as the network that connects the end users. Many hospitals face upgrading the network infrastructure in advance of rolling out CPOE. Though basic infrastructure needs will not vary much from one vendor to another, some of the special options for remote access and wireless communications have different requirements.

### **Points to consider in evaluating technology**

- The product technical architecture and fit with the hospital's technical strategy.
- The application architecture including the CPOE application. What legacy applications would be replaced or duplicated? What are the technical complexities of managing the new application architecture?
- Interfaces that will be required between the CPOE application suite and legacy applications. Which interfaces will be new for this vendor and product? To what extent is the vendor willing to guarantee delivery and performance of application interfaces?
- The options for achieving the necessary real-time integration with pharmacy processes and IT. How would synchronization of updates to pharmacy formulary and order master

files be maintained? How would the data flows between physician orders, pharmacist order verification, and nurse medication administration be managed?

- Experience with reliability and response time of the vendor product in hospitals of similar size and complexity.
- Special requirements for network infrastructure to accomplish mobile computing for physicians and for nurses, as applicable.

## **Cost**

Hospitals are accustomed to looking at the acquisition and maintenance costs of software applications and related investments in processing and end user hardware. For CPOE, the challenge is greater because the options are likely to involve different application architectures and approaches to swapping out existing applications and thus not an “apples to apples” cost comparison. Evaluating the costs of each option realistically requires considering the parallel differences in implementation—both process and IT. With one approach there may be more users to train (e.g., because the pharmacy application will be involved or clinical documentation is involved). Another may involve a different server architecture and related investments.

Every hospital faces cost tradeoffs when considering adding CPOE from the legacy HIS vendor versus other options. Staying the course with the current vendor probably allows more re-use of existing applications and lower implementation costs because fewer software applications are swapped out. When other options are examined, many of the costs of a CPOE effort are not determined by the specific vendor solution. However, there are some areas where there may be cost tradeoffs to consider. Some solutions would require a particular end user device involving an additional purchase, for others a different effort (and cost) to integrate the applications.

Vendors offer different purchase and payment approaches that can spread out payments for the hospital. Some hospitals will want to consider arrangements such as processing provided through an Application Service Provider (ASP) or outsourcing relationship.

### **Points to consider regarding cost**

- The options available for software license. One-time fee, per user fee, use fee?
- Remote computing, outsourcing or ASP options available.
- Vendor experience and services relating to interfacing the CPOE application suite with legacy applications.
- Costs of vendor-supplied training and other implementation support.

## **Risk**

Any project involves risk. Given the fact that CPOE is a largely uncharted path for the industry—both for hospitals and for vendors—this effort involves more risk than most. Risk is, however, not a showstopper. Rather, prudence requires identifying and exploring the implications of risk so that they can be managed.

CPOE products are all relatively new and less proven than other software applications hospitals purchase. Organizations tend to fall into different groups when it comes to innovation and to taking risks. In some, the leadership and medical staff relish being pioneers and innovators and that role is integral to the mission and culture. In others, the role of follower or even late adopter is more comfortable and is the path more commonly taken. This posture will establish the general boundaries within which the relative risks of CPOE solutions are interpreted.

### Points to consider regarding risk of using different vendor solutions

- Market experience of vendor and track record of successful implementations. What is known about the ability of the vendor to deliver implemented solutions?
- Extent of product experience, preferably in similar hospitals. How much has the CPOE solution been road-tested?
- Industry and customer hospital experience with the technical architecture employed. To what extent has the scalability of the approach and performance been proven?
- Number of other hospitals already committed to using the CPOE solution. What will the likely backlog of implementation sites be when it is the hospital's turn to implement?
- Profile of other customer hospitals. Who else in the industry will be driving the research and development agenda?
- Willingness of vendor to peg payments to implementation milestones and/or to otherwise go at-risk for successful implementation and performance.

### Implementation Planning

The focus of this report has been on one of the early tasks for hospitals implementing CPOE—sorting out the appropriate software solution. Once the decision has been made, there is much more for a hospital to do.

In fact, most of the investment in CPOE occurs as the hospital prepares for, and accomplishes the rollout of electronic ordering. Given the complexity of the process, the intersections with other processes, and the many decisions to make, the task is large. Some of the pioneers recognized by the Nicholas Davies program for their accomplishments have estimated that for every dollar invested in acquiring (or developing) the system, successful rollout requires an investment of two to three dollars in implementation support (staff devoted to implementation, costs and time devoted to training, change management activities). [4]

Implementation challenges are greater on the organizational side than with technology. Ideally, planning for implementation and putting accountability and structure in place to accomplish implementation, are well underway by the time the CPOE solution has been selected. Industry experience with successful adoption of CPOE is limited, but growing rapidly. Resources listed in Appendix C can provide a good starting point for connecting with the growing body of industry knowledge about how to implement CPOE successfully hospital-wide.

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## Appendix A. CDS Functions and Features

All of the *detailed features* within each category of CDS are described in Table A-1 below. Two important characteristics of each feature are also noted:

- *Active or passive.* Active decision support happens automatically as the physician is entering orders, whereas passive decision support requires the physician to locate the desired information or request assistance. Both are useful, but play different roles in supporting decisions and actions. The obvious advantage of active decision support is that it pops up in circumstances where the physician is not aware of the potential problem. Examples of active decision support are a message alerting the physician that the patient has a reported allergy to the medication being ordered or a system edit that only allows the physician to order a medication to be administered via a particular route. Passive decision supports include order sets (which the physician must select) and facilitated access to relevant clinical knowledge such as the dosing recommendations for a medication or the clinical research upon which a recommended practice is based.
- *Supporting doing things right or doing the right things.* Clinical decision support can improve ordering in two distinctly different ways. First, for any service being ordered, the physician is assisted in ordering correctly by advice. For example, the physician may receive information about dosing for a medication or by being guided to the medication actually stocked in the hospital. In this case, the assistance provided aids the physician in ordering correctly. The second type of contribution is assistance in combining what is known about a patient and their clinical condition with recommended best practices. This helps the physician “do the right things.” Examples include checking for contraindications among medications and allowing users to gain access to order sets by specifying diagnosis. As indicated in Table A-1, some decision support features contribute in both of these ways. For example, an order set includes appropriate orders pre-written for each ordered service, as well as the recommended set of clinical orders for the clinical situation (such as admission for hip replacement, pneumonia).

For looking at individual vendor offerings, it was also important to differentiate basic CDS functions that are relatively easy to implement but provide immediate value because they apply to a large percentage of the orders written from those that expand the scope of coverage to lower volume, highly specialized orders or add refinements to the delivery of decision support. Shaded features in Table A-1 were considered a “basic” level of decision support.

Table A-1. CPOE Clinical Decision Support Features by Category

Clinical Decision Support		Mode		Nature of Support	
Functionality	Description	Active	Passive	Do Things Right	Do the Right Things
<b>Basic Field Edits</b>					
Order field format checking	Requires spaces between words and numbers; no trailing 0's, etc.	✓		✓	
Required fields	Data must be entered in the field in order to complete the order	✓		✓	
Checks for correct data type	Numerical versus text entry in field	✓		✓	
<b>Structured Orders</b>					
Structured orders: route, dose, frequency, duration	Template containing fields to be completed in order for this intervention	✓		✓	
Required fields	Fields in template that must be populated	✓		✓	
Default values	Order fields pre-filled with most typical value for this intervention	✓		✓	
Series orders/recurring orders	Single order display for intervention ordered for multiple times	✓		✓	
Preset allowable value for route of administration	Route of administration for that medication and hospital formulary	✓		✓	
Preset allowable value for available doses	Set according to medication and hospital formulary	✓		✓	
Check against hospital formulary	Link between hospital formulary and medications that can be ordered	✓		✓	
Electronic counter-signature by user type	Requirement for a countersignature (e.g., med student orders pending until countersigned by attending)	✓		✓	
Electronic countersignature by intervention	For specific orders with additional countersignature required (e.g., all chemo orders countersigned)	✓		✓	✓
Display of cost information	Inclusion of intervention cost or charge as part of order template	✓		✓	✓
<b>Groups of Predefined Orders</b>					
Standard order sets and ordering regimens	Sets of orders available as a starting point for patient-specific ordering		✓	✓	✓
Common order sets	The subset of orders most likely to be relevant to the physician		✓	✓	✓
Common orders	Usually by specialty, a shortcut to the most commonly-used orders		✓	✓	✓
Order sets linked to clinical pathways	Multiple order sets included in a clinical pathway		✓	✓	✓
Order set by diagnosis	Suggested orders for user-specified diagnosis		✓		✓

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Table A-1. CPOE Clinical Decision Support Features by Category (Continued)

Clinical Decision Support		Mode		Nature of Support	
Functionality	Description	Active	Passive	Do Things Right	Do the Right Things
Corollary/linked orders for adjunct interventions	Prompting to order recommended associated orders (drug levels when ordering medication)	✓			✓
Vendor-supplied starter sets	Library of common orders by clinical department, order sets, clinical pathways to speed implementation	—	—	—	—
<b>Order Checking with and without a Reference Database</b>					
Drug-drug interaction checking	Automatic checking for drug-drug contraindication	✓			✓
Drug-allergy interaction checking	Automatic checking against documented allergies	✓			✓
Drug- food interaction checking	Automatic checking for contraindicated foods	✓			✓
Drug-disease interaction checking	Automatic checking against patient diagnosis or problem list	✓			✓
Therapeutic duplication checking within a drug class	Automatic checking for duplicate therapy	✓			✓
Therapeutic duplication checking within the same therapy (same drug)	Automatic checking for same medication	✓			✓
Therapeutic duplication checking with components of combination products	Automatic checking for therapeutic duplication, including components of product	✓			✓
Single dose limit checking	Automatic dose range checking	✓		✓	
Dose limit checking for each component of a combination product	Component-level dose range checking	✓		✓	
Medication checking of off-formulary items	Application of rules for medications not listed in hospital formulary but contained in third-party drug reference file	✓		✓	✓
IV incompatibility checking	Check for incompatible ingredients in custom IV order	✓			✓
Duplicate order checking	Check for same order within X hours (typically lab test)	✓		✓	
Cost-of-care checking	Advisory message that less expensive medication is recommended	✓			✓
Exception documentation for alert overrides	Text entry that is added to order with alert – preferred method is selecting from a menu list of coded reasons	✓		✓	✓

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Table A-1. CPOE Clinical Decision Support Features by Category (Continued)

Clinical Decision Support		Mode		Nature of Support	
Functionality	Description	Active	Passive	Do Things Right	Do the Right Things
<b>Complex Orders with Specialized Tools</b>					
Complex admin times and dosages for medication orders	Specialized templates for orders involving taper dosing or alternate day dosing, entered as a single order,	✓		✓	
Patient-specific dosing	Dose calculator or display of calculated dose based on documented weight, BSA, age, and/or lab results (such as renal function), as appropriate to the medication	✓		✓	
Sliding scale orders	Specialized template for sliding-scale dosing (e.g., insulin)	✓		✓	
Conditional orders	Orders with status pending based on patient event (transfer to OR) or condition (fever exceeds 102)	✓		✓	✓
IVs	Specialized templates for ordering IVs with customized additives	✓		✓	
Patient-controlled analgesics	Specialized templates including order parameters for PCAs	✓		✓	
Adult TPN ordering	Templates for specifying customized total parenteral nutrition	✓		✓	
Adult chemotherapy ordering	Templates including parameters needed for chemotherapy	✓		✓	
Pediatric TPN ordering	Templates for specifying customized total parenteral nutrition	✓		✓	
Pediatric chemotherapy ordering	Templates including parameters needed for chemotherapy	✓		✓	
<b>Order – Relevant Patient Data Display</b>					
Automatic display of relevant patient information for that order	Display specific lab test results or trends as part of the order entry process for the medication	✓			✓
<b>Order – Relevant Patient Data Capture</b>					
Requirement for weight, height, or other information necessary for dosing	Required capture of patient-specific information needed for clinical decision support; may be captured during assessment	✓		✓	✓
Requirement for allergy documentation	Required capture of patient-specific information needed for clinical decision support; may be captured during assessment	✓		✓	✓
Linked appropriateness criteria requiring entry of data	Prompt to document clinical indications for intervention being ordered	✓			✓

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Table A-1. CPOE Clinical Decision Support Features by Category (Continued)

Clinical Decision Support		Mode		Nature of Support	
Functionality	Description	Active	Passive	Do Things Right	Do the Right Things
<b>Rules Based Prompting and Alerts within Order Entry</b>					
Customer-definable rules combining logic (nested "if's") and available patient data	Rules engine for writing CDS logic and responses	✓		✓	✓
User-friendly rule writer	Tool permitting rule writer to use English language to identify parameters and logic statements rather than requiring programming language	—	—	—	—
Cumulative dose limit checking	Dose checking for relevant medications for episode or lifetime	✓		✓	
Contraindication/dose limit checking based on patient diagnoses	Use of patient diagnosis in checking for contraindications or dose limits	✓		✓	✓
Contraindication/dose limit checking based on age/weight	Use of patient age/weight in checking for contraindications or dose limits	✓		✓	✓
Contraindication/dose limit checking based on lab studies	Use of information on patient status from lab studies in checking for contraindications or dose limits	✓		✓	✓
Contraindication/dose limit checking based on procedures	Use of information on recent or scheduled procedures with contrast media in checking for contraindications	✓			✓
Patient-specific information drives allowable values for specified fields	Based on the insurance plan for the patient, the appropriate formulary list	✓			✓
Facilitated response to recommendation	Via buttons, 'yes,' or other means, tools to make it easy to follow recommendations by adding or modifying order	✓		✓	✓
Support to Arden Syntax	Facilitates sharing of rules across institutions, use of commercial libraries of rules	—	—	—	—
Context-specific links to clinical knowledge	For a given alert or recommendation, easy access to the clinical research upon which it is based		✓	✓	✓
Vendor-supplied knowledge base or rules	Library of knowledge to facilitate building of rules-based decision support	—	—	—	—

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Table A-1. CPOE Clinical Decision Support Features by Category (Continued)

Clinical Decision Support		Mode		Nature of Support	
Functionality	Description	Active	Passive	Do Things Right	Do the Right Things
<b>Rules Based Prompting and Alerts Outside of Order Entry</b>					
Expiring orders alerts	Notice to caregiver that order is about the expire	✓			✓
Alerts based on new patient information – allergy or diagnostic test result	New patient information triggers message to re-evaluate current patient orders. Message relayed when caregiver signs on to system	✓		✓	✓
External notification	Same as above, with notification by multiple modes not requiring user to be logged onto system – nursing station, MD pager	✓		✓	✓
Coverage list	Same as above, with notification based on physician covering the service	✓			✓
Escalation	Escalation rules for alerts based on severity and length of time without response	✓			✓

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## Appendix B. Contact Information for CPOE Vendors

Vendor/Corporate Address	Contact Information
<b>Autros Healthcare Solutions, Inc.</b> Yorkdale Place One Yorkdale Road Suite 310 Toronto, Canada M6A 3A1	Tova Manett VP of Marketing and Communication Phone: (800) 537-2255 Web site: <a href="http://www.autros.com">www.autros.com</a>
<b>Cerner Corporation</b> 2800 Rockcreek Parkway Kansas City, MO 64117	Joe Ketcherside, MD Director Physician Practices Phone: (816) 201-3495 Fax: (816) 201-9495 Web site: <a href="http://www.cerner.com/">http://www.cerner.com/</a>
<b>CliniComp International</b> 9655 Towne Center Drive San Diego, CA 92121	Alan Portela Vice President of Sales and Marketing Phone: (800) 350-8202 Fax: (858) 546-1801 Web site: <a href="http://www.clinicomp.com">www.clinicomp.com</a>
<b>Eclipsys Corp</b> One Boston Place Boston, MA 02108	Chris Carson Corporate Strategy and Market Development Phone: (678) 256-4608 Fax: (678) 256-4677 Web site: <a href="http://www.eclipsys.com">www.eclipsys.com</a>
<b>Epic Systems Corporation</b> 5301 Tokay Boulevard Madison, WI 53711	Carl Dvorak Chief Operating Officer Phone: (608) 271-9000 Web site: <a href="http://www.epicsystems.com">www.epicsystems.com</a>
<b>GE Medical Information Systems</b> 8200 West Tower Avenue Milwaukee, WI 53223	Sachin Kheterpal, MD General Manager, Marketing Clinical Information Systems Phone: (734) 994-9321, ext. 114 Web site: <a href="http://www.gemedicalsystems.com/">http://www.gemedicalsystems.com/</a>
<b>IDX Systems Corporation</b> 1001 Fourth Avenue Plaza Suite 1500 Seattle, WA 98154	John L. Foy, MD Director, Orders and Pharmacy Phone: (206) 689-1150 Fax: (206) 667-9782 Web site: <a href="http://www.idx.com/">http://www.idx.com/</a>
<b>McKesson</b> Information Technology Solutions 5995 Windward Parkway Alpharetta, GA 30005	Phone: (800) 981-8601 Web site: <a href="http://www.mckesson.com/">http://www.mckesson.com/</a>
<b>Medical Information Technology, Inc. (Meditech)</b> Meditech Circle Westwood, MA 02090	Jennifer Sagerian Physicians Consultant Phone: (781) 774-5160 Web site: <a href="http://www.meditech.com/">http://www.meditech.com/</a>

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**Appendix B. Contact Information for CPOE Vendors (continued)**

Vendor/Corporate Address	Contact Information
<b>Per Se Technologies</b> 2840 Mt. Wilkinson Parkway Atlanta, GA 30339	Mathew Morgan, MD Director of Healthcare Informatics Phone: (877) 73PerSe (toll free) 770-444-4000 Web site: <a href="http://www.per-se.com">www.per-se.com</a>
<b>Siemens Medical Solutions Health Services Corporation</b> 51 Valley Stream Parkway Malvern, PA 91355	Floyd Eisenberg, MD Physician Consultant Phone: (610) 219-8547 Web site: <a href="http://www.smed.com/">http://www.smed.com/</a>
<b>3M Health Information Systems</b> 575 W. Murray Boulevard Murray, UT 84157	Phone: (801) 254-4400 Web site: <a href="http://www.3mhis.com">www.3mhis.com</a>
<b>VisualMED Systems</b> 2600 North Military Trail Suite 349 Boca Raton, FL 33431	Robert Cohen Vice President, Sales and Marketing Phone: (888) 567-9447 Web site: <a href="http://www.vmedsys.com">www.vmedsys.com</a>

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## Appendix C. Additional Resources on Computerized Physician Order Entry

American Hospital Association. *AHA Guide to Computerized Physician Order Entry Systems*. Chicago: AHA, November 2000.

Birkmeyer JD., Birkmeyer CM, Wennberg DE, Young M. *Leapfrog Patient Safety Standards: The Potential Benefits of Universal Adoption*. The Leapfrog Group, November 2001. <http://www.leapfroggroup.org/PressEvent/birkmeyer.pdf>

Birkmeyer, JD, Birkmeyer CM, Skinner JS. *Leapfrog Patient Safety Standards: Economic Implications*. The Leapfrog Group, June 2001. <http://www.leapfroggroup.org/toolkit/LF.Costs.final.pdf>

Drazen E., Kilbridge P, Metzger J, and Turisco F. *A Primer on Physician Order Entry*. California HealthCare Foundation and First Consulting Group. September 2000 [http://www.fcg.com/webfiles/pdfs/CPOE\\_Report.pdf](http://www.fcg.com/webfiles/pdfs/CPOE_Report.pdf)

Kelly B. Case study. Order entry gets out of hand. *Health Data Management* 9(7):20-24, July 2001. ([www.healthdatamanagement.com](http://www.healthdatamanagement.com) )

Kilbridge P. and Classen D. *A Process Model of Inpatient Medication Management and Information Technology Interventions to Improve Patient Safety*. 2001 Research Series, Volume 1. Irving Texas: VHA, Inc., 2001.

Metzger J. and Slye D. Inpatient e-ordering. *Healthcare Informatics* May 2001: 63-67, 2001. <http://www.fcg.com/webfiles/pdfs/HealthcareInformatics-eOrdering.pdf>

Weir C, Lincoln M, Roscoe D, and Moreshead G. Successful implementation of an integrated physician order entry application. A systems perspective. *Proceedings of the Nineteenth Annual Symposium on Computer Applications in Medical Care*. 1995: 790-794.

Six winners of the Nicholas E. Davies Award for Excellence in CPR Implementation were recognized in part for their successful implementation of inpatient CPOE. Essays describing the approaches taken and lessons learned are available in the Symposium Proceedings for the following years:

Year Two	Brigham and Womens Hospital (Boston)
Year Three	Regenstreif Institute (Indianapolis)
Year Five	Queens Hospital (Honolulu)
Year Six	VA Puget Sound (Seattle)
Year Seven	University of Illinois (Chicago) and Ohio State University (Columbus)

Copies of the proceedings can be obtained from CPRI-HOST ([www.cpri-host.org](http://www.cpri-host.org) or 301-657-5918). Check with CPRI-HOST for details about the Annual Davies Symposium where award-winning organizations describe their approaches and lessons learned.