# PREVALENCE AND CHARACTERISTICS OF COMPUTERIZED PROVIDER ORDER ENTRY SYSTEMS IN THE US

by

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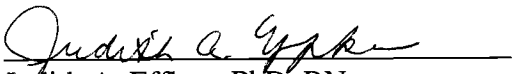

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# ABSTRACT

Though computerized provider/physician order entry (CPOE) has received great attention in recent years as a means to reduce medical errors, studies to determine its prevalence and characteristics are limited. This descriptive study was undertaken to replicate and extend the work of Ash, Gorman and Hersh (1998) via a telephone survey in an effort to determine the change in prevalence of CPOE over time as well as characteristics of systems in place, characteristics of facilities with and without CPOE in place, goals of CPOE, formal CPOE evaluation completion and plans to implement CPOE. A total of 189 responses were received which revealed a/an, (1) decrease of 18% in the prevalence of CPOE, (2) increase in inducement, (3) increase in participation, (4) increase in the saturation. Characteristics of CPOE systems and the facilities in which they are in use are described in this study, as well as CPOE goals. Plans for CPOE implementation in the respondent facilities are also discussed.

# CHAPTER 1

## STATEMENT OF THE PROBLEM

Stimulated by health care's growing focus on patient safety, computerized provider order entry (CPOE) is emerging as a priority in healthcare information technology (IT). Despite this growing impetus to implement CPOE very little is known about the prevalence and characteristics of CPOE and the facilities that employ these systems. This study was undertaken to replicate and extend the work of Ash, Gorman and Hersh (1998) to determine the change in prevalence of CPOE over time as well as the functionality of the systems in place and selected characteristics of the facilities in which CPOE is in use.

The term CPOE refers to direct entry of medical orders into a computer system by physicians/providers who are licensed/authorized to write prescriptions for medical treatment. The CPOE system/software may accommodate entry of all medication and clinical orders by the provider in a "module" that is integrated with many other modules/interfaced systems (e.g., laboratory, radiology) to form a health information system (HIS), or, it may refer to a more limited provider order entry of only specific types of orders (e.g., medication orders). CPOE may also function as a standalone system that is not interfaced or integrated with other clinical systems, though this configuration is less likely, as functionality and clinical benefits would be limited. CPOE systems have received much attention from various arenas as a means to reduce errors.

The well-publicized Institute of Medicine (IOM) Committee on Quality of Healthcare in America reports *To Err is Human: Building a Safer Health System* and *Crossing the Quality Chasm: A New Health System for the 21st Century* have provided momentum to proactively reduce errors in medical care via information technology (IT) and redesign of the healthcare delivery system (Kohn, Corrigan, & Donaldson, 1999; Institute of Medicine, 2001). *To Err is Human* discusses preventable life-threatening medical errors that may be experienced by patients entering healthcare facilities and *Crossing the Quality Chasm* discusses the need to evaluate the healthcare system as a whole. The IOM reports have prompted a strong response by the health care industry and by state and federal governments. The reports were followed by a variety of patient safety initiatives, several which endorse CPOE as a means to reduce medical errors.

The IOM acknowledges that CPOE systems may decrease medical errors, a point which the Washington-based Leapfrog Group (a coalition of healthcare purchasers from public and private organizations and Fortune 500 companies which works with medical experts throughout the U.S. to promote patient safety by improving hospital systems) concurs (Kohn, Corrigan, & Donaldson, 1999; Computer Physician Order Entry, 2003). In fact, the Leapfrog Group has pledged to purchase health care services from organizations that use CPOE and comparative data analysis tools and has listed CPOE as one of its three key patient safety initiatives (Computer Physician Order Entry, 2003). This may prove to be a powerful incentive for healthcare organizations to implement CPOE.

Leapfrog and the IOM reports have spurred an interest in electronic solutions to common precursors of medical errors. Kohn, Corrigan, & Donaldson (1999) report that more than one million medication errors occur every year in US hospitals. About half of these errors occur at the stage of medication ordering and include such errors as incorrect medication dose, frequency or route, and illegibly written orders/prescriptions (Bates, Cohen et al., 2001; Bates, Cullen, Laird et al., 1995; Kaushal, Bates, Landrigan, Mckenna, Clapp, Federico et al., 2001). Medication errors have been identified as major contributors to complications or injury in hospitalized patients (Kohn, Corrigan, & Donaldson, 1999; Bates, Cullen, Laird et al., 1995). CPOE systems, particularly those with decision support (displays of clinically relevant patient data at the time of order entry) can address errors such as incorrect route, dose, frequency, etc. CPOE systems also reduce illegibility and associated transcription errors by providing typewritten/computer-generated orders.

CPOE provides many advantages that have been well documented in the literature. These advantages include elimination of handwritten orders, identification of the prescriber, rapid routing of orders to clinicians and departments, and decision support to reduce adverse events caused by incorrect doses, drug-drug interactions, and allergic reactions (Kohn, Corrigan, & Donaldson, 1999; Shane, 1999). CPOE can also reduce expenditures by guiding providers to use more cost-effective therapies thus optimizing treatment planning and resource use (Shane, 1999; Meadows & Chaiken, 2002).

The national discussion of the benefits of CPOE and an emphasis on improving quality in US hospitals has encouraged legislators and regulatory agencies to place a priority on its implementation. With the potential for CPOE to become the standard of care, and healthcare facilities undergoing a digital transformation it behooves us to understand the technologies currently in place in the United States (US). Knowledge of these systems, prevalence of their implementation, and the variations therein may assist in determining the impact that legislative mandates might incur. Identifying characteristics and functionality of current CPOE systems will inform us of what actually exists in healthcare facilities and will provide a knowledge base for further research.

## Purpose of the Study

The current study was undertaken to replicate and extend the work of Ash, Gorman and Hersh (1998) in an effort to determine the change in prevalence of computerized provider order entry (CPOE) over time. Ash et al. (1998) created a postcard survey to be mailed to a systematic sample of 1,000 United States (US) hospitals selected from the *American Hospital Association (AHA) Guide* (1997). The objective of this research was to identify the percent of hospitals in the US that had CPOE systems in place. The mailed survey response rate was 33% (324 respondents). A random sample of 41 non-respondent hospitals was contacted via telephone resulting in a total response rate of 37% (365 respondents). The original study concluded that most US hospitals (66%) did not have CPOE available. Indeed, complete availability of CPOE systems was

rare with few facilities requiring its use. Survey comments indicated many hospitals were actively planning to make CPOE available in the near future.

In the original study (Ash et al., 1998) the following questions were asked:

1. Availability: Computerized order entry by physician is (please circle letter)
    a. Not available at all (no system in place for use by physicians)
    b. Partially available (offered in some form or in some locations)
    c. Completely available (all orders can be entered in all locations)
    d. Was formerly available (system previously in place was abandoned)
2. Inducement: Computerized order entry by physicians is (please circle letter)
    a. Optional (available, and there is no active program to increase use)
    b. Encouraged (program in place to encourage use; other options are discouraged)
    c. Required (no other option exists except in emergencies)
3. Participation: Please estimate the percent of physicians using computerized order entry (place an X anywhere on the line). [A visual analog scale was given]

4. Saturation: Please estimate the percent of orders by physicians using a computer (place an X anywhere on line). [A visual analog scale was given]

This initial survey was the first phase in the Ash research group's efforts to identify success factors in implementing CPOE.

The primary purpose of the proposed research is to determine the percent of change in CPOE prevalence in the time span between Ash et al's (1998) initial study and the present time. The proposed descriptive study will re-survey the 324 facilities that responded to the Ash et al. (1998) postcard survey study. In addition to replicating the original research additional data will be gathered to identify facility demographics, system usage, integration, participation, saturation, type of system, functionality, goals and evaluation, will be described for facilities that currently employ CPOE systems. For those facilities that have not implemented CPOE, plans to implement will be identified including the projected time frame for implementation. Characteristics of facilities which currently employ CPOE systems will be compared to those facilities that do not in an effort to determine basic implementation patterns. The results of this research will provide a basis for further studies regarding CPOE prevalence as well as contribute to the knowledge base concerning current CPOE functionality and implementation patterns.

## Research Questions

1) How has CPOE prevalence in the Ash et al. surveyed healthcare facilities changed since the original survey?

a) What is the availability of the systems in place?

b) CPOE use is (a) optional, (b) encouraged, or, (3) required (inducement)

2) How long has the CPOE system been in place (duration)?

3) What is the estimated percentage range of providers using CPOE (participation)?

4) What is the estimated percentage range of orders entered by providers using the CPOE system (saturation)?

5) What are the characteristics and functionality of the CPOE systems currently in place? The characteristics of interest include:

a) Type of product (internally developed vs. vendor product)

i) If a vendor product, vendor and/or software name

b) Incorporation of decision support

c) Types of decision support incorporated

d) Use of predefined order sets

e) Integration with other clinical systems

f) Remote order entry capabilities

6) Are there differences in the characteristics of facilities which employ CPOE and those which do not employ CPOE?

7) Were the goals for the CPOE system met?

8) Has the CPOE system been formally evaluated?

9) If CPOE is not currently in place are there plans to implement CPOE in your facility?

## Definitions of Key Terms

- Adverse drug event (ADE): An adverse drug event is any injury resulting from a medical intervention related to a drug. It may range in severity from mild to severe (About Medication Errors, 2000; Leape, 2000).
- Availability: the extent the CPOE system can be accessed from all locations (Ash et al., 1998).
- Characteristics of CPOE systems: unique features of individual facility's CPOE systems that may or may not contribute to its functionality (e.g., product type, decision support systems, predefined order sets, integration with clinical systems).
- Characteristics of facilities: selected data from the AHA annual survey such as (1) bed size, (2) admissions, (3) membership in a healthcare system, (4) affiliation, (5) control, (6) service, (7) physician arrangement relationships, (8) location, etc.
- Computerized provider order entry: a process which allows a provider to use a computer to directly enter medical orders. The process eliminates the need for an intermediary to respond to written or verbal orders given by a provider by transferring them to the laboratory (lab) or elsewhere (adapted from Ash et al., 1998, p. 236).
- Decision support system (DSS): A computer program application that analyzes data and presents it so that users can make decisions more easily. A

DSS may present information graphically and may include an expert system. (Metzger & Turisco, 2001).

- Functionality: individual characteristics of a CPOE system such as DSS and integration that contribute to its effectiveness.
- Health care information system (HIS): a computer system comprised of integrated modules for various areas/departments both clinical and administrative used in a healthcare environment.
- Inducement: the extent to which CPOE usage is encouraged or required (Ash et al. 1998).
- Integration: the sharing of information across information system (IS) modules; supporting links with existing systems (e.g., laboratory, pharmacy, nursing).
- Medication error: any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer (About Medication Errors, 2000).
- Participation: the number of providers using CPOE at a given facility (Ash et al. 1998).
- Prevalence: The pervasiveness of CPOE system implementations.

- Provider: Those that provide healthcare services and who are licensed/authorized to write prescriptions for medical treatment (e.g., physicians, nurse practitioners).
- Saturation: The percentage of orders entered by providers at a given facility (Ash et al. 1998).
- Usage: number or percentage of providers using CPOE systems.

## Background and Significance

Healthcare has often been viewed as an industry that spurns the use of IT; but for the first time, not incorporating IT may mean noncompliance with regulatory agencies or laws. Proposed mandates for technology implementation such as the (1) Medical Error Reduction Act of 2000 (S. 2038), introduced in the Senate, requiring that any hospital that admits more that 20,000 patients annually be required to use CPOE systems (*Medical Error Reduction Act of 2000*) which has been referred to the Committee on Health, Education, Labor, and Pensions, and, (2) the California State Legislature Senate Bill number 1875, passed in late 2000 and now Section 1339.53 of the California Health and Safety Code, which requires most California hospitals to adopt technology that has been shown to substantially reduce medication errors. Section 1339.63 requires hospitals and clinics (with the exception of small and rural hospitals) to have a plan approved by the State Health Department by the end of 2002 and a system in place by the end of 2004 (*California Senate Bill No. 1875,* 2000). In addition the Joint Commission on

Accreditation of Healthcare Organizations (JCAHO) has supported the establishment of a federal program to fund information systems.

Mandates for IT implementation may have disastrous effects on a healthcare industry that is struggling financially due to decreasing provider payment, balanced budget ramifications, fixed payment systems for inpatient and outpatient care and rising costs. Investments in technology can obviously be beneficial, but are also costly to implement. Finding the time and funding for IT implementation is a challenge for many healthcare facilities/systems. Yet, inserting IT into the care process and using automation to gain efficiencies and improve patient safety are increasingly viewed as strategic and clinical imperatives (HIMSS, 2003; Tieman, 2001).

The IOM report has had a resounding effect on healthcare facilities. It has become apparent that solutions to increase patient safety must be implemented without delay. One of the proposed solutions is implementation of CPOE systems, particularly those systems with DSS that are integrated with clinical system modules. Overhage, Tierney, Zhou & McDonald (1997) supported this concept in their study employing simple DSS concepts to encourage providers to order corollary orders for specific tests and medications. In their research they found that physicians who received DSS reminders at the time of ordering were twice as likely to order the suggested test. The current study will attempt to identify those CPOE systems that utilize DSS technologies to provide appropriate clinical data/warnings at the time of order entry as well as

integration with other clinical modules such as laboratory, radiology, nursing, dietary, etc. (see APPENDIX A for research survey).

According to Richard Diefes of ECRI, a non-profit international health services research agency, "CPOE systems are getting a lot of attention as a means to reduce medication errors, but they do not catch everything and commercial CPOE systems still represent and evolving technology" (Evaluating CPOE, 2002). Some assert that we continue to lack products that meet the needs of both the health care facility and the end-user (Drazen, Kilbridge, Metzger, & Turisco, 2000). The evolutionary nature of CPOE products may be a factor in Ash et al. (1998) findings that only 32.1% of surveyed hospitals had CPOE fully or partially available. Ringold, Santell & Schneider (1999) conducted research on hospital-based pharmaceutical services and determined that only "13% of hospitals had an electronic medication order-entry system" (p. 1760). These statistics indicate that CPOE was not well entrenched in US hospitals at that time.

Massaro (1993) described the difficulties experienced at the University of Virginia (UVA) when mandatory CPOE was initiated. This implementation instigated confrontational meetings between hospital administration and medical staff. Though some of the difficulties Massaro outlined were system related, the majority were related to changes in work processes and practices. CPOEs impact on work processes and practice patterns must be acknowledged and incorporated into implementation planning (Ash 1997; Massaro, 1993; Sittig & Stead, 1994).

The true value of CPOE systems is realized (1) when they are integrated with HIS modules developed for all clinical areas (e.g., laboratory, pharmacy, radiology) and/or data repositories, and (2) incorporate decision support systems (DSS) and current patient information (e.g., allergies). When these modules are well integrated, the software can identify possible interactions between ordered medications, determine if lab values preclude the use of certain medications, identify errors of omission, and calculate medication doses based on patient specific information. Real-time alerts can then be given to the provider to modify or cancel identified orders. Integrated CPOE systems with DSS have proven to have a positive impact on patient safety by prompting changes in orders placed for medications for higher than maximum recommended dosages, dosages that should be modified based on specific information (e.g., lab values), drug–drug interactions, patient allergies, etc. All of these features, and the process of order entry itself, combine to increase ordering accuracy, legibility (thus reducing transcription errors), and communication of orders to ancillary departments (Bates, 1999b; Bates, 1999c; Bates, Cullen, Laird et al., 1995; Leape et al., 1995; Evaluating CPOE, 2002; Murff & Kannry, 2001; Sittig & Stead, 1994).

A recent Healthcare Information and Management Systems Society (HIMSS) Leadership Survey confirms that healthcare information technology (IT) executives feel that patient safety is the top concern. Fifty-two percent of the respondents reported that "implementing technology to reduce medical errors and/or promote patient safety was the top IT priority at their facility today" (Prus, 2003, p.1). Additionally 64% of the

respondents to the HIMSS survey identified computerized provider order entry as "the application that they considered to be most important to their organization" (Prus, 2003, p. 1). Though CPOE has received incredible focus, in 2001 there were no more than 13 CPOE software/system products available in the US (Metzger & Turisco, 2001).

While research has been conducted on various aspects of CPOE, such as ADE reduction and DSS, there are few studies that focus on functionality of the systems that are in use. It has been identified that decreasing fragmentation of patient care information locations as well as logical presentation of this clinical information is beneficial to end-users (Institute of Medicine, 2001). CPOE systems that are integrated to gather patient information from several different modules provide exceptional advantages. The ability to combine information from laboratory, pharmacy, radiology and assessment modules and present the crucial portions of this information in a logical manner to the provider will make CPOE systems invaluable. The ability of privileged providers to access this integrated patient information from any networked computer and/or dialup service will enhance service provision by placing information at the point of care (Metzger & Turisco, 2001). Integrated information will allow providers to enter orders via CPOE modules that reflect any needed adjustments based on the patient's current status. In addition, the availability of legible and complete provider orders may well benefit all patient care providers. Finally, there is some evidence to suggest that CPOE reduces "turnaround time" (Drazen, Kilbridge, Metzger & Turisco, 2000) for ordered services.

Researchers (Drazen, Kilbridge, Metzger & Turisco, 2000) have identified that the financial resources needed to develop CPOE/HIS systems internally are prohibitive. Rising pressure to implement CPOE will likely result in health care facilities purchasing existing vendor-developed products. There is currently little data to identify the present deployment of vendor versus internally developed products. While implementation of the pre-packaged product may be accomplished with greater ease than developing a product in-house, it will still require the use of many resources.

Undoubtedly there is no health care facility that undertakes CPOE implementation lightly. The process changes both the culture and the nature of work for a diverse group of healthcare personnel. Initial planning for CPOE implementation is likely to include goal development and evaluation planning. This study will attempt to identify examples of those goals and whether they were met as well as identify if a formal evaluation has been completed. Cataloging these processes may serve to identify as yet unreported benefits of CPOE systems.

Several factors, such as increases in medical information resulting from biomedical research, advances in IT, decreasing IT costs, portable technology, increased computer literacy, and pressure from healthcare purchasers, managed care organizations and regulatory agencies will likely result in more widespread use of CPOE (Metzger & Turisco, 2001; Sittig & Stead, 1994; Tieman, 2001). The shifting paradigm from single-purpose, isolated information to multi-purpose, easily accessible information will also

serve to push CPOE solutions forward. Change is inevitable, but change must be tempered with knowledge and foresight.

This study is expected to contribute to the knowledge base regarding one IT solution for healthcare, CPOE. It will identify currently employed CPOE system characteristics and use. A literature review reveals that there is little research information regarding these aspects of CPOE. As we gain more knowledge about current CPOE systems we can more readily identify those factors that impact functionality as well as patient safety. Though CPOE has been touted as a system revision that will significantly reduce errors, very little is known about characteristics of these systems in the US.

## Summary

Various market and regulatory forces are encouraging or mandating the use of CPOE. Recent research indicates that CPOE systems are not prevalent; moreover, there are few CPOE products available in the US. Presently, there is little research that addresses the change in prevalence of these systems over time, or their characteristics and usage. This descriptive replication study will gather information about current CPOE system functionality and characteristics in an effort to contribute to the knowledge base and cumulative history of research regarding these systems.

# CHAPTER 2

# CONCEPTUAL ORIENTATION AND LITERATURE REVIEW

## Theory

The University of Arizona College of Nursing's adaptation of the Quality Health Outcomes Model (QHOM) developed by the American Academy of Nursing Expert Panel on Quality of Health Care (Mitchell, Ferketich & Jennings, 1998; see Figure 1) was used to guide this research. The adaptation of the QHOM entitled Systems Research Organizing Model (SROM) is listed in Figure 2 (J. Effken, personal communication, August 22, 2002). This dynamic model is predicated on the recognition of reciprocal directions among the four concepts identified: (1) client, (2) context, (3) interventions, (4) outcomes, and the system analysis/innovation process. The concept of client may consist of an individual, family or community and the associated characteristics. Context is defined as individual, organization or group and includes both structure and process elements. Interventions may include treatments, process changes, and/or technology introduction. Outcomes are the results of care structures and processes. The premise is that these concepts interact with and affect one another (J. Effken, personal communication, August 22, 2002; Mitchel, Ferketich & Jennings, 1998).

Figure 1. Quality Health Outcomes Model.

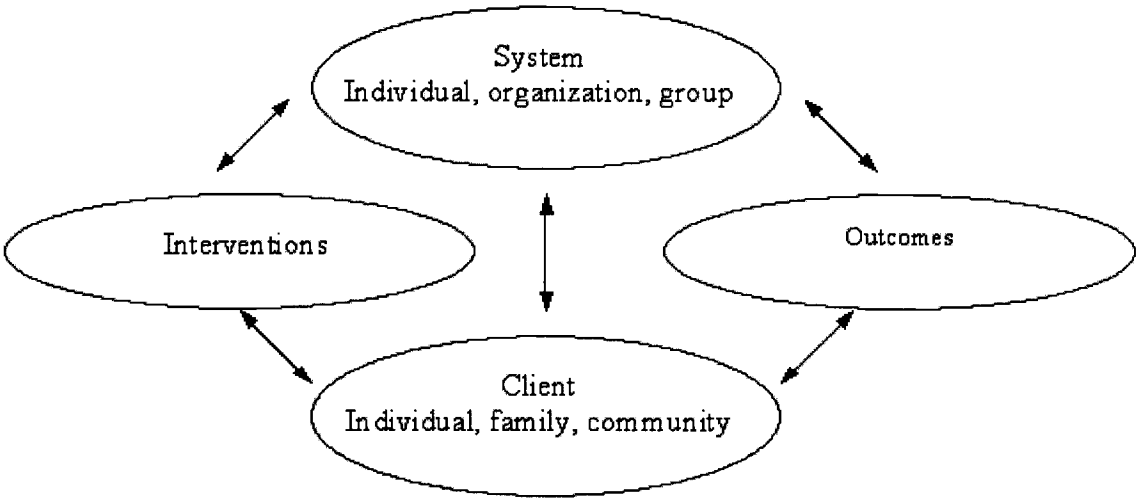
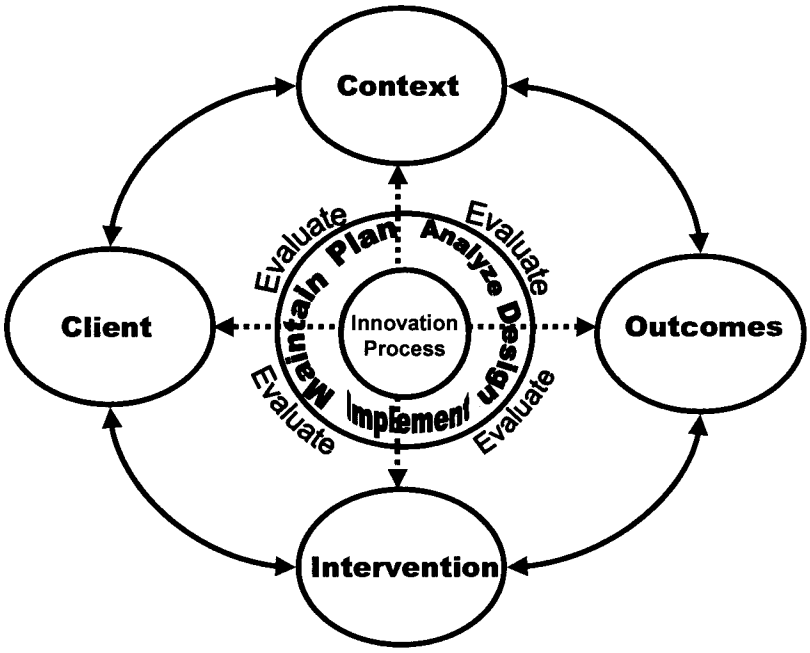
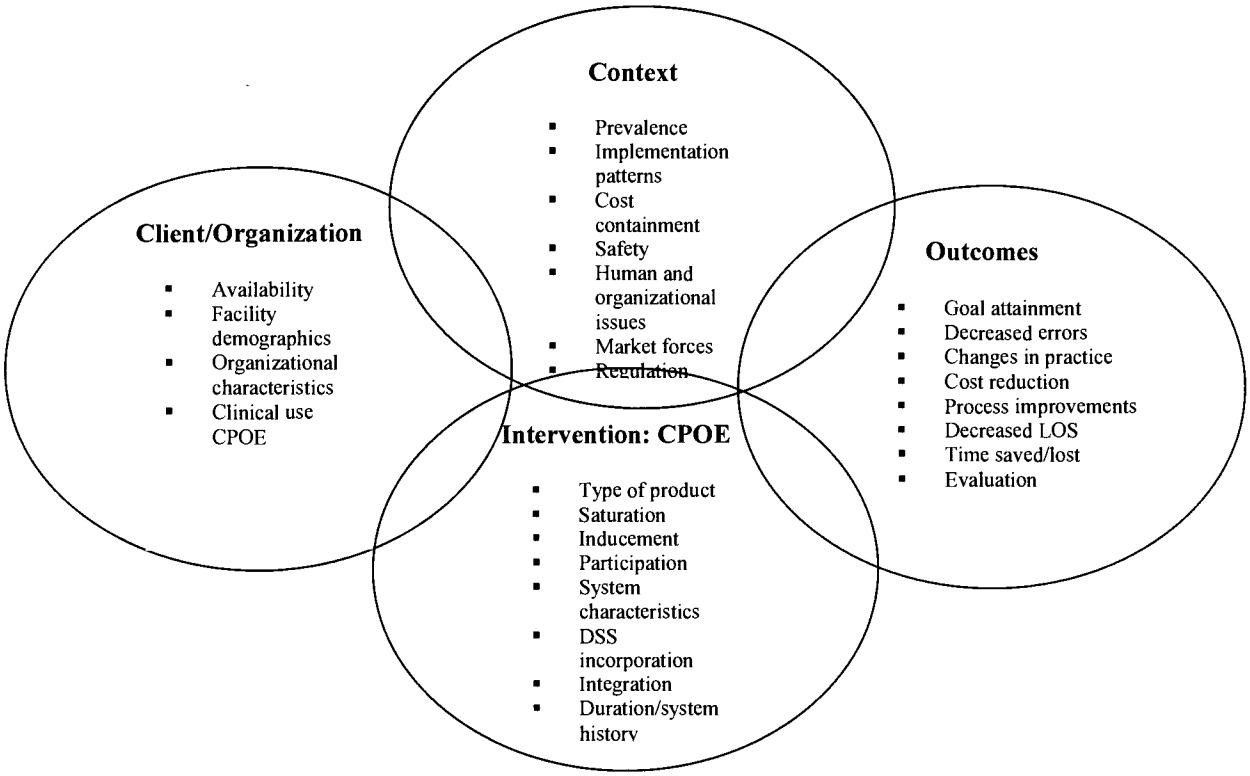


Figure 2. Systems Research Organizing Model (SROM-I).




A modification of the SROM was developed for CPOE research (see Figure 3). The modified model represents the symbiotic relationship between the four core concepts. The core concepts of client, system, intervention and outcomes are defined below. The concepts directly addressed by the current research are illustrated in Figure 4.

Figure 3. Theoretical Model for CPOE Research (adaptation of SROM-I).

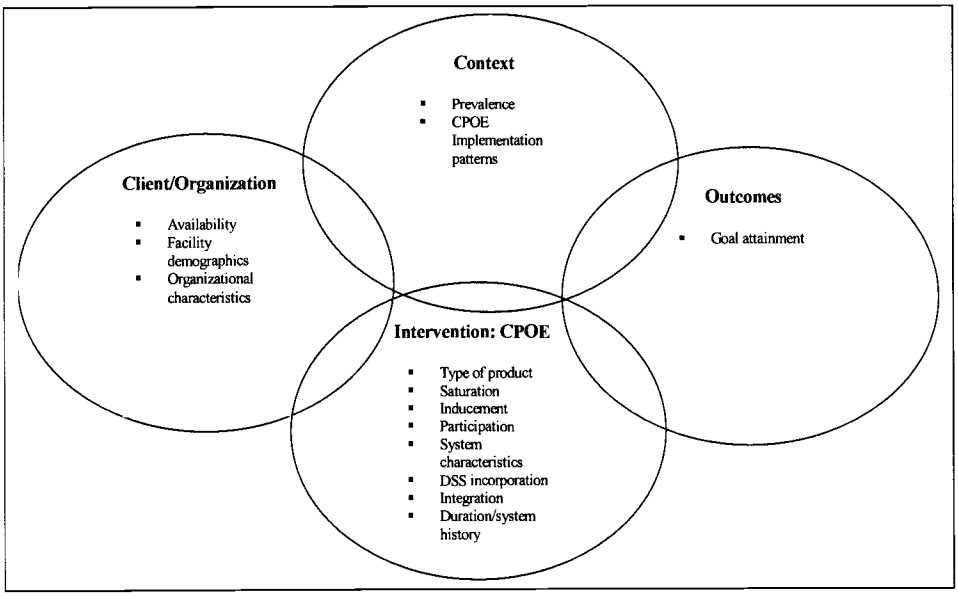



In the adapted model:

- Client/Organization: encompasses organizational components such as availability of CPOE, facility demographics (e.g., staffed beds, admissions), organizational characteristics (e.g., control, membership in healthcare system), and the clinical (end-user) use of CPOE systems.
- Context: includes CPOE implementation patterns, cost containment needs, safety promotion needs, human and organizational issues, market forces and regulation

- Intervention: includes type of product, saturation, inducement, participation, system characteristics (e.g., use of order sets), DSS incorporation, integration, and system duration/history.
- Outcomes: includes changes in prevalence of CPOE, goal attainment, reduction in errors, changes in provider practice, cost reductions associated with CPOE, process improvements, decreased LOS and changes in time spent ordering/documenting

Figure 4. Research Model (adaptation of SROM).



# Literature Review

Current interest in CPOE has been fueled by the IOM report which concluded that patients are being harmed as a consequence of care (Kohn, Corrigan & Donaldson, 1999). Research indicates that CPOE systems can have a positive effect on patient safety issues, costs, decreased errors, and practice standardization/process improvements (Bates et al., 2001; Leape et al., 1998). These potential benefits are impressive; however, CPOE implementation affects multiple aspects of an organization. Recognition of this may well have inspired research into human and organizational issues regarding CPOE implementation and use (Aarts & Peel, 1999; Bates, Kuperman & Teich, 1994; Kaplan, 1997; Kaplan, et al., 2001; Lorenzi, et al., 1997; Massaro, 1993; McDonald, Hui & Smith, 1984).

Much of the applicable research was performed in institutions where CPOE is one module of an integrated HIS. CPOE gains functionality in these systems because alerts, reminders and decision support are based on full access to a patient's current clinical information (e.g., pharmacy, laboratory, assessment). The increased functionality of the integrated system may make it more common than a standalone application (Bates et al., 1998; Bates, 1999a; Bates, 1999b; Bates, Kuperman & Teich, 1994; Chin & Wallace, 1999; Lombardi, 2000; Tokarski, 2000).

The reviewed literature reveals several studies that were conducted in large and/or academic facilities. Most of these studies are individual studies that examine particular aspects of CPOE or its implementation (Ash, n.d.; Bates et al., 1998; Bates, 1999a; Bates,

1999b; Bates, Kuperman & Teich, 1994; Chin & Wallace, 1999; Lombardi, 2000; Tokarski, 2000). The current body of literature includes little information about the use or characteristics of current CPOE systems beyond what can be extrapolated based on studies conducted in individual facilities.

CPOE can be a powerful tool in managing the order process. With an integrated system and DSS, orders can be reviewed and checked in real-time for any available supporting information, guidelines, warnings, and alerts. Thus one no longer has to rely upon the provider to retain a list of medications and items available from Pharmacy Services (formulary) at a specific facility, recommended dosage information can be supplied immediately, menus or "pick lists" can display only the appropriate doses for each medication, overrides (bypassing warnings/alerts) can be limited and audited, guidelines and protocols can be displayed for review and patient specific information can be prominently displayed.

## Context

### Human and Organizational Issues

There is (at least) one universal component of CPOE – people both implement and use CPOE systems. Recent research regarding human and organizational issues includes both CPOE and HIS implementations thus both will be included here. Successful implementation of CPOE/HIS is highly culture dependent. Undeniably, healthcare facilities have many similarities; however, there are differences in culture and practice in each institution. CPOE/HIS should be designed around individuals within

each unique setting. The literature supports the conclusion that attention to the human and organizational issues is paramount in successful implementations of both HIS and CPOE. As in any organization, relationships between the organization itself, HIS/CPOE users, and internal and external forces form a myriad of interactions and interrelationships. The implementation of IT solutions invites a complex change process encompassing these interactions and interrelationships that alters both the organization and the people within it (Aarts & Peel, 1999; Kaplan, 1997; Kaplan, et al., 2001; Lorenzi, et al., 1997).

HIS impacts many aspects of human relationships, workflow, and organizational culture (Kaplan, 1997). Lorenzi et al. (1997) support the organizational alteration and human aspects of HIS implementation. In fact, they state that "today's informatics implementations – and especially the larger scale ones – are becoming increasingly dependent upon how well the people and organizational issues are managed" (p.79). Informatics literature is replete with discussions of HIS/CPOE implementations that have either failed or had limited success at least in part due to failure to recognize these issues (Bates, Kuperman & Teich, 1994; Massaro, 1993; McDonald, Hui, Smith et al., 1984).

Providers have expressed their concerns about IT and its effects on patient care. These concerns include: (1) the ability to maintain privacy and confidentiality of the patient record, (2) security of the electronic form of patient information storage and retrieval, (3) the potential for IT to dehumanize the patient-provider interaction, (4) IT imposed limitations on practice variations that individualize care to patient needs (Ash,

Stavri & Kuperman, 2003; Tierney, Overhage & McDonald, 1997). These general concerns, as well as more specific concerns of each implementing facility's providers must be addressed prior to CPOE implementation.

Concerns about end-user resistance to technology have developed. Valenta & Wigger (1997) attempted to determine underlying sources of resistance to technology by utilizing Q-methodology to categorize the opinions of primary care physicians (PCPs) and medical students regarding their reasons for acceptance of and/or resistance to adapting IT in the health care workplace. Their research suggests, "the opinions of PCPs and medical students toward information technologies in the health care workplace are more closely related to their medical practice philosophy than to systems functionalities" (p.509). Thus, the technology may not be the root of implementation issues; it may be the "underlying healthcare ideology driving the technology" (Valenta & Wigger, 1997, p.509). Indeed, CPOE implementation planning must include the entire healthcare team. Plans must include evaluation of how IT can support organizational goals and positive work process changes rather than retrofitting organizational systems to accommodate IT and clinicians (Schiff & Rucker, 1998). Diane Carr, associate executive director for healthcare information systems at Queens Health Network states that "physicians know what they need to take care of patients, and the information system needs to support that. The whole [implementation] effort is less about technology and more about change management. It's more about people" (Baldwin, 2003, p. 36).

Safety

A large number of medication errors (49%) occur at the ordering stage (Jha et al., 1998; Kilbridge, 2001). CPOE's ability to improve this stage of the order cycle is one reason why it has attracted so much attention as means of reducing medication errors. Bates (1999b) found that implementation of CPOE with DSS features (e.g. drug allergy and interaction warnings) decreased all types of medication errors (dose, frequency, route, substitution and allergic interaction errors). Bates reports that some types of errors were reduced by as much as 81% with the advent of DSS. Evans et al. (1994) found that computerized ADE surveillance, coupled with alerts to pharmacists about drug allergies, standardization of antibiotic administration rates, and physician notification about ADEs, reduced ADE rates.

Additional studies (Bates et al., 1998; Bates, 1999a; Chin & Wallace, 1999; Lombardi, 2000; Tokarski, 2000) outline a 55-81% reduction in ADEs post-CPOE implementation due to the increased availability of data as well as DSS features. These systems may also play a role in the 19% reduction of all types of ordering errors discovered by Bates et al. (1998) post CPOE implementation. This system change was also shown to reduce transcription errors by 84% (Bates, 1999b; Lombardi, 2000; Tokarski, 2000).

While the evidence seems to suggest that CPOE can significantly reduce errors, there are some anecdotal reports that it may also lead to medication errors as a result of inadvertently selecting the wrong patient, drug, or administration time or unintentionally

discontinuing medications. Of course, these same errors can be made in handwritten orders which have no ability to provide instant feedback as would a CPOE system with DSS. In some systems DSS systems/safety checks can be bypassed by the use of free text to enter orders as opposed to selecting orders from predefined "pick lists" within the system (Kilbridge, 2001; Shane, 2002).

There is a concern that technological changes such as CPOE with DSS and other safety features will deskill clinicians, causing them to become dependent on the technology's decision support/alerts rather than their own education and experience and internal knowledge. DSS alerts may encourage complacency on the part of health care providers who may believe that the systems built in safety checks will not allow an incorrect order (Shane, 2002). There is some evidence to the contrary; Burris (1993), suggests that computerized technology may enhance, rather than undermine, the work of the physician (as cited in Burris, 1998, p. 150). Perrow (1983) speaks to the need to design systems to promote exchange of task-relevant information. In essence, Perrow's (1983) work indicates that to be most effective, the technology must incorporate and encourage overlapping, intersecting and interdependent workflows that comprise the healthcare team. Freidson (1984) states that computerization may not adversely affect professionals, since "it is the members of each profession who determine what is to be stored and how it is to be done, and who are equipped to interpret and employ what is retrieved effectively" (as cited in Burris, 1998, p. 150).

There is also a potential to "over-alert" clinicians, which may lead them to ignore all alerts. There is a delicate balance between useful alerting and nuisance alerts that must be balanced with patient safety in mind (Skjei, 2002). This balance must bear in mind the findings of Ebbesen et al. (2001) that many ADEs were not recognized by the involved clinicians at the time of the occurrence.

Though CPOE may present new challenges, it has the potential to benefit patient care. In fact, strategies to reduce the incidence of medication errors frequently point to the positive role that technology can play. Clearly implementation of CPOE (or any IT solution) is not a rapid fix; but well designed systems can positively impact patient care by decreasing medication errors/ADEs, reducing patient readmissions due to drug interactions, and improving outcomes (Bates, 1999b; Kilbridge, 2001; Lombardi, 2000; Tokarski, 2000).

## Client/Organization

### Prevalence/Availability

Results of historical research indicates that CPOE does not enjoy widespread availability in US hospitals. Ash et al. (1998) determined that only 32.1% of US hospitals had CPOE completely or partially available. A recent Medical Records Institute (MRI) poll also found that "at least 30% of healthcare organizations may already have some form of computerized physician order entry" (as cited in Versel, 2003). Ringold et al. (1999) determined that only 13% of surveyed hospitals had an electronic medication order-entry system, though 27% reported they were in the process of

developing this type of system. This concurs with Ash et al. (1998) findings "many respondents indicated that their hospitals [were] actively planning to make CPOE available in the near future" (p.237). The Healthcare Information and Management Systems Society (HIMSS) 14th Annual Leadership Survey (HIMSS, 2003), which supports Ash et al. and MRI findings that many facilities are evaluating CPOE implementation. The HIMSS survey respondents indicated that the four application areas considered most important for healthcare clients over the next two years are (1) enterprise-wide clinical information sharing, (2) computer-based patient record, (3) clinical information systems, and, (4) CPOE. An annual survey completed by Dorenfest & Associates, Ltd. in 2002 also supports this interest in CPOE. The Dorenfest survey indicates that 37.19% ($n$=164) of the respondents ($n$=441) are considering acquisition of a CPOE system to support patient safety efforts (Dorenfest, 2003).

One of the benefits of CPOE is the ability to enter orders from any location within a facility (availability). Some systems also allow providers to enter orders remotely. Ash et al. (1998) discuss availability of CPOE systems. Of the 32.05% respondents that reported in place CPOE systems 46.15% had complete availability of the system and 53.85% reported partial availability.

Organizational Characteristics

Research specific to characteristics of those healthcare facilities that have/have not implemented POE is limited. However, research on technology initiation and adoption has been completed in other business sectors. Four major formal structural

characteristics that influence organizational technology initiation and adoption characteristics have been identified: (1) organizational size, (2) specialization, (3) centralization, and, (4) formalization (Grover & Goslar, 1993). Though some have argued that smaller organizational size allows for greater flexibility to foster technology adoption, the greater propensity of the research suggests that larger organizations are more likely to proceed with innovations (Grover & Goslar, 1993). A diversified technical staff (specialization) has also been shown to positively affect technology initiation and adoption. Centralized decision-making activity appears to positively affect adoption and negatively affect implementation. Formalization in the guise of more formally defined work procedures inhibits initiation and adoption (Grover, Fiedler & Teng, 1997; Grover & Goslar, 1993). Greater degrees of formalization may be indicative of more formally bureaucratic organizations, which have been associated with less adaptability to innovation (Morgan, 1997).

Less risk is associated with adoption of mature technologies thus making their adoption more likely. New or "cutting-edge" technologies may be considered unproven or prone to unexpected defects that may affect business operations negatively ((Grover V, Fiedler K, & Teng J, 273-1987). Several factors that affect technology initiation and adoption have been identified by researchers including: (1) organizational size, (2) specialization (technical staff), (3) centralization of authority, (4) formalization (formally defined work procedures), (5) organizational experience with computer technology, (6) existing IT infrastructure, (7) resource availability, (8) business sector, (9) information technology maturity, (8) organizational commitment to advanced technology (9)

bureaucracy, (10) culture, (11) costs , (12) environmental uncertainty, and, (12) environmental heterogeneity (see Table 1) (Bretschneider & Wittmer, 1993; Franz & Roby, 1986; Grover et al. 1997; Grover et al., 1993; Lehman, 1985; Swanson, 1994).

Kaplan et al. (2001) recognize that the organizational structures of healthcare organizations are changing rapidly in efforts to respond to regulatory requirements, cost containment needs and patient and public requests. Snyder-Halpern (1999) states that environmental factors and health care setting characteristics "can jointly or independently influence the innovation customization process...and the innovation implementation process" (p. 120). She also recognizes the individual facility structural characteristics (internal environmental readiness) affect innovation readiness. Lorenzi et al. (1997) identify organizational structure and type as two of several components of healthcare IT implementation success.

Table 1. Organizational and Environmental Characteristics Influencing Technology Initiation and Adoption.

| **Organizational Characteristic** | **Facilitator** | **Inhibitor** |
|---|---|---|
| Organizational size | Large | Small |
| Specialization (technical staff) | Diverse technical specialists | Homogeneity |
| Centralization (authority) | Decentralized | Centralized |
| Formalization (formally defined work procedures) | Informal | Formal |
| Prior experience with technology | Experience | Inexperience |
| Infrastructure (IT) | Adequate | Inadequate |
| Resource availability (funds, personnel, etc.) | Abundance | Lack |
| Sector | Public | Private |
| Maturity of existing technology | Mature | Current |
| Organizational Commitment to IT | High commitment | Low commitment |
| Bureaucracy | Low | High (formal, machine) |
| Culture | Open | Closed |
| **Environmental Factors** | **Facilitator** | **Inhibitor** |
| Technology costs | Modest | Excessive |
| Uncertainty | Uncertainty | Stability |
| Heterogeneity | Diversity | Homogeneity |

Intervention

Decision Support Systems (DSS) / Adverse Drug Events (ADEs) / Errors

DSS can range from very simple data field checks to more complex operations, such as calculations and comparisons. The literature addresses the broad category of medication errors (any preventable event that may cause or lead to inappropriate medication use or patient harm) and the more specific subcategory of ADEs (any injury resulting from a medical intervention related to a drug) and the potential of CPOE to decrease these errors and increase patient safety via tools such as incorporation of DSS, access to information, and/or alerts and reminders. These systems provide guidance and/or incorporate knowledge that assists the provider in entering complete, accurate and

appropriate patient care orders (Metzger & Turisco, 2001). All of these feature have the greatest impact on potential ADEs.

Studies to determine the cause of ADEs point to errors in all stages of the medication-use cycle: (1) planning, (2) prescribing, (3) transcription, (4) dispensing, (6) administration, and (7) monitoring. These errors may be based in part on inadequate dissemination of knowledge and inadequate availability of patient data (Bates et al., 1995; Jha et al., 1998). Metzger, Stablein and Turisco (2002) purport that one of the most fundamental forms of decision support is up-to-date information presented in a clinically relevant way. An integrated CPOE system with DSS can improve the medication process and assist clinicians in providing optimal care. CPOE alerts, reminders, correct medication dose "pick lists," predefined order sets, increased legibility, and access to patient information, all serve to improve the medication-use cycle and decrease ADEs (Kuperman, Teich, Gandhi & Bates, 2001).

Integration / Delimiters

Historically the healthcare industry has invested fewer resources into the development of information system (IS) technology, as compared with other service industries that rely heavily on information. For example, the banking and insurance industries have typically invested from 7 to 10 percent of operating expenses in information technology, whereas the healthcare sector averages around 2 percent of operating expenses annually. Furthermore, resources expended on computer hardware and software have only recently been focused on integrated information systems (Moran, 1998). Bates et al. (2001) report that "many healthcare organizations are hamstrung,

because they have implemented so many different technologies that information stays in silos" (p.306). In fact, in their 2003 survey Sheldon I. Dorenfest & Associates, Ltd., found that 56.1% of responding healthcare delivery systems use 10 or more software suppliers (Dorenfest, 2003). It is hoped that the advent of standards for the exchange of information such as HL7 have improved the ability to integrate information from disparate legacy systems (an information system that has been in use for a long time, usually on a mainframe computer) (Hunt, Haynes, Hanna & Smith, 1998). Data integration between lab, pharmacy and clinical information are critical to gaining the greatest value from CPOE (Able, 2001).

Predefined order sets and other CPOE medication ordering structural features assist in decreasing errors. Predefined order sets allow the provider to choose an entire group of orders with a few keystrokes or clicks of the mouse. This reduces errors in dosage and decreases the amount of time the provider must spend entering orders. The use of formulary dictionaries that include associated common doses limits the chance for error in both dose and drug selection. Maximum dose checking may reduce the likelihood of excessive doses of any medication being administered. CPOE systems can warn providers of potential dose modifications needed due to a patient's impaired renal function (e.g., as determined by creatinine clearance calculation utilizing data from lab results). Duplicative medication orders can be significantly reduced via computerized checking measures. Many, if not all, of the aforementioned features are enabled/enhanced via integration with other clinical systems (e.g., lab, pharmacy). The

direct communication of CPOE with an integrated pharmacy system reduces transcription error both on the part of the provider and the pharmacist (Bates et al., 1998; Kuperman et al., 2001).

## Saturation / Inducement / Participation

Ash et al. (1998) found that 4.9% of the facilities that employed CPOE required its use. This may explain why 52.2% had fewer than 10% of their orders entered by medical staff. More than half of the respondents (57.7%) indicated that orders were entered utilizing the CPOE system less than or equal to 10% of the time. Only 9% of the responding facilities indicated that orders were entered via the CPOE system greater than 90% of the time. Participation (the percent of staff using the system) was 50% or less in 60.2% of the facilities (Ash et al., 1998). Dorenfest (2003) found that "less than 20% of the delivery systems surveyed had some physicians entering some orders directly into the computer systems, and only a few delivery systems had most of their physician entering some or all orders into their computer systems" (p. 34). Negative experiences such as those outlined by Massaro (1993) may be influencing organizations' plans to require CPOE use.

## Outcomes

### Cost / Charge reduction

Cost reduction is defined as decreasing the cost of patient care via DSS technology embedded within the CPR, with no significant impact on patient outcomes

(Bates, 1999a). Several studies indicate that computerized reminders to physicians regarding redundant laboratory tests, alternate medications/doses, and inappropriate medication usage (e.g. antibiotics) resulted in significant cost savings (Bates, 1999a; Bates et al., 1998; Chin & Wallace, 1999; Evans, Pestotnik, Classen, & Burke, 1999; Sado, 1999; Seger, 1999; Tierney et al., 1997). These cost savings were not limited solely to preventing ADEs, but also to ADE related events such as decreased LOS costs and deferring costs of potential litigation related to the event. Classen et al. (1997) concluded that direct hospital costs of ADEs during a one-year period were close to $1,099,413 and that 50% of these events were preventable. In addition, standard provider order sets, duplicate order checking, standardizing dosage and administration, and checking against hospital/health plan formularies have been determined to cut costs (Able, 2001; Bates et al., 1997; Drazen, Kilbridge, Metzger & Turisco, 2000). Tierney, Miller, Overhage & McDonald (1993) found that inpatient CPOE led to a 13% reduction in acute care inpatient charges.

Evans et al. (1999) demonstrated that a computer assisted management program for antibiotics substantially decreased costs and improved quality of care in an ICU by reducing the number of times allergic reactions were experienced by patients and providing prompts and information to improve the appropriateness of antibiotic dosing based on calculations such as creatinine clearance. The dose monitoring system had a positive effect on patient outcomes by reducing ADEs and reducing excessive medication dosages. The dosage monitor prompted fewer grams of antibiotics to be administered

over the course of the ICU stay which resulted in a cost savings. Bates et al. (1997) estimate that the annual costs attributable to preventable ADEs in the study facility were $2.8 million. These findings suggest that computerized alerts, reminders and monitors may improve both clinical and financial outcomes though the financial savings have been challenged by some as not being applicable to hospital setting in a fee-for-service environment (Doolan & Bates, 2002).

Decreased Errors

CPOE can positively contribute to system changes that reduce errors by issuing alerts to the provider consisting of specific information bits or sets, offering suggestions for order changes when appropriate, suggesting orders based on information previously gathered, and providing evaluative functions that can contribute to process improvements (Huag et al., 1994). Screening for drug-drug, drug-allergy, and drug-disease interactions, links to lab results, and monitoring for adverse events all contribute to decreasing errors associated with provider orders (Bates, 2000; Bates, et al, 1999b; Chin & Wallace, 1999).

Changes in Length of Stay (LOS)

CPOE can impact patient care in several ways. The integrated system can provide for a greater coordination of care due to accessibility of relevant patient data, DSS can trigger specific alerts and reminders, and process changes can increase the completeness of patient documentation. These items alone, or in concert, may serve to affect LOS. Tierney et al. (1993) found that implementation of a CPOE system on a medical service resulted in a reduction of the average length-of-stay (LOS) by 0.89 days and a 12.7%

reduction in charges. Those patients who experienced ADEs were hospitalized an average of 1-5 days longer than those who did not (Classen et al., 1997)

Process improvements

CPOE has been shown to reduce lost orders, decrease intermediary transcription of orders, and eliminate ambiguities due to illegible handwriting and/or incomplete orders. It also has been shown to reduce time to fill drug orders, schedule tests, notify consultants, and in combination with a fully integrated HIS may reduce redundancy of processes. Indeed, implementations of the Seimens' CPOE systems have resulted in "a 25% reduction in turnaround from the time a lab order is placed until the result is back from the lab, a 43% reduction in radiology turnaround time, and a 64 percent reduction in medication turnaround time" at Ohio State University Medical Center and a "64% reduction in medication turnaround time" at Rush Presbyterian-St. Luke's in Chicago (as cited in Skjei, 2002, p. 5). CPOE, in concert with an HIS, can offer standard order sets, formulary listings and online protocols and the like, which assist in practice standardization, process improvements and overall time savings (Bates, 1999a; Schiff & Rucker, 1998; Sittig & Stead, 1994).

Changes in Practice / Standardization

Teich et al. (2000) demonstrated that CPOE recommendations to providers upon entering orders changes ordering behavior. In their study, use of a computerized guideline resulted in recommended changes in usage of study medications. They caution, however, that the guidelines that the recommendations are based on must be "developed

through, and sanctioned by, a strong and effective hospital pharmacy and therapeutics committee" (p. 2745). They found that those alerts/reminders that were considered controversial received less provider compliance than those that had been considered accepted practice.

Evans et al. (1999) demonstrated that a computer assisted management program improved quality of care in an ICU. One of the components of the system was providing prompts and information to improve the appropriateness of antibiotic dosing based on calculations such as creatinine clearance. Prompts were well accepted by the providers in the study and the recommendations were often followed. The dose monitoring system had a positive effect on patient outcomes by reducing ADEs and excessive medication dosages. Other studies have shown similar results regarding provider acceptance of computerized alerts and changes in practice due to these alerts (McDonald et al, 1984; McDonald, Hui & Tierny, 1992).

Time

CPOE enables several process changes that may improve patient care and/or safety; however, it has been proposed that this comes at a direct cost to the provider in terms of time. Massaro (1993) reported that increased time spent on CPOE tasks (as compared to paper processes) caused providers to vehemently resist its implementation. Subsequent studies have determined that CPOE introduction does add time to the ordering process. In Shu et al. (2001) study there was a 9% increase in the amount of time spent on order tasks with CPOE. Overhage, Perkins, Tierney & McDonald (2001)

found an increase of 2.2 minutes more per patient when CPOE was utilized. Both studies indicate that this is counterbalanced by time saved due to CPOE enhancements and by improvements in patient care and quality and efficiency changes. Interestingly, Weiner et al. (1999) report that after CPOE implementation 56% of nurses in the study facility indicated that their time with patients increased. This was attributed to system/process improvements directly resulting from CPOE.

## Summary

In this chapter, the conceptual framework for the study was described and literature reviewed related to each concept in the framework. The study will employ the SROM framework to facilitate the analysis of the structure of the variables related to CPOE systems and their characteristics, as well as the settings in which the systems are found. Although, many studies have presented the benefits of CPOE and discussed the problems associated with implementation, there is little information about CPOE prevalence or characteristics.

# CHAPTER 3

## METHODOLOGY

The purpose of this descriptive research was to determine the percent of change in CPOE prevalence in the sample study originally surveyed by Ash et al. (1998). This replication study was accomplished via telephone interviews. The respondents were interviewed utilizing a modified version of Ash et al. (1998) survey that included additional questions regarding the characteristics of installed CPOE systems. The data gathered were analyzed in an attempt to answer the following questions:

1) How has CPOE prevalence in the Ash et al. surveyed healthcare facilities changed since the original survey?
    a) What is the availability of the systems in place?
    b) CPOE use is (a) optional, (b) encouraged, or, (3) required (inducement)
2) How long has the CPOE system been in place (duration)?
3) What is the estimated percentage range of providers using CPOE (participation)?
4) What is the estimated percentage range of orders entered by providers using the CPOE system (saturation)?
5) What are the characteristics and functionality of the CPOE systems currently in place? The characteristics of interest include:
    a) Type of product (internally developed vs. vendor product)
        i) If a vendor product, vendor and/or software name
    b) Incorporation of decision support
    c) Types of decision support incorporated

d) Use of predefined order sets

e) Integration with other clinical systems

f) Remote order entry capabilities

6) Are there differences in the characteristics of facilities which employ CPOE and those which do not employ CPOE?

7) Were the goals for the CPOE system met?

8) Has the CPOE system been formally evaluated?

9) If CPOE is not currently in place are there plans to implement CPOE in your facility?

## Research Design

A descriptive research design was employed to determine characteristics of CPOE systems. A telephone survey research design was chosen as this focuses on obtaining information regarding a specific topic via direct questioning of a sample of respondents (Polit & Hungler, 1999). Direct questioning allowed maximization of the number of completed interviews, which was expected to reduce non-response bias (Salant & Dillman, 1994). The questions on the survey replicate Ash et al's (1998) study with additional questions added to further identify specific characteristics of current CPOE systems (see APPENDIX E for complete survey). Efforts were made to have questions be clear, follow a logical sequence, and require little time and effort on the part of the respondent (Salant & Dillman, 1994).

Telephone administered surveys offer many advantages over in-person interviews and mail surveys. Telephone surveys are less costly, more flexible, and require less time than aforementioned survey options. Additional advantages include the ability to ensure

that one has contacted the appropriate person to answer the survey, low refusal rates, high completion rates, and efficiency (Polit & Hungler, 1999; Salant & Dillman, 1994)

Joan Ash, Ph.D. and the Physician Order Entry Team (POET) collaborated on the design of this study. Joan Ash, Ph.D. serves as the principal investigator for the POET team based in the Division of Medical Informatics & Clinical Epidemiology (DMICE) at Oregon Health & Science University (OHSU). The POET team investigates CPOE implementation issues using a variety of methods. They have been awarded a number of grants for the purpose of gathering evidence regarding CPOE implementation success and failure factors, evaluating, interpreting and validating that evidence, and disseminating the findings (www.cpoe.org).

## Sample Selection Criteria

Ash et al.'s (1998) sample database was used for this research. The initial sample selection included a "random sample of 1,000 accredited hospitals ...selected [via a systematic sampling] from among those listed in the American Hospital Association Guide [1997], a directory of all accredited hospitals in the US" (p. 236). The replication study involved contacting the 324 facilities that originally responded to Ash et al. (1998) postcard survey in an effort to determine their current CPOE status. The surveyed facilities were located throughout the US.

## Protection of Human Subjects

Permission for the conduct of this study was obtained from the University of Arizona Institutional Review Board (see APPENDIX B). All data were entered into a

computer database compiled from survey respondents' information. The data were reported in aggregate form with no individuals identified to protect the confidentiality of the respondents. Any data used for this study was kept on computer disk and deleted using standard deletion methods within five years of completion.

The purpose and nature of the study were explained to each respondent in verbal format. Verbal permission to conduct the study survey was obtained from each individual respondent. Respondents were assured of the confidentiality of their responses and of their right to stop the interview at any time with no repercussions whatsoever. Names of the subjects were confidential with only the principal investigator (PI) and her sponsors having access to the information.

## Instrument Development

To elicit responses directly pertinent to the research questions proposed, a telephone survey based on Ash et al.'s (1998) original work was developed specifically for this study (see APPENDIX E). In an effort to add to the knowledge base regarding characteristics of current CPOE systems and clarify information gathered, several questions were added to the original Ash et al. (1998) survey questions in this replication study. Joan Ash Ph.D. and P. Zoe Stavri Ph.D. (a member of the POET team) collaborated on the development of the additional questions.

Due to the modicum of information regarding what specific types of facilities have implemented CPOE, several demographic questions were added to the survey. In addition, facility specific demographic information from the AHA Guide (2000) was

entered into the database and correlated with the respondents to both reduce the number of facility specific questions the respondents were requested to answer as well as provide a more comprehensive depiction of the surveyed facilities. Rationale for the additional questions is provided in Table 2. The rationale underlying the entire study was a desire to provide information that may fill the gaps in the current literature such as characteristics of facilities that have implemented CPOE, and, functionality of CPOE systems that are currently in place across the US. Once the survey questions were developed it was pre-tested with a group of experts familiar with healthcare information systems (HIS) to assess applicability and ease of use. The pretesting resulted in modifications to the wording of five questions and a reordering of questions by topic group.

Table 2. Rationale for Survey Questions.

| Survey Question | Rationale |
|---|---|
| Topic Group: CPOE History | |
| Is CPOE in place in your facility? | Replication question |
| What is the availability of the CPOE system? | Replication question |
| Length of time CPOE has been in place? | Gains a historical perspective of how long CPOE systems have been in use. |
| Are there plans to replace your current CPOE system? Timeframe? Reason? | May (1) provide insight into deficiencies of legacy CPOE systems, and/or, (2) assist in determining life cycle of CPOE systems. |
| Is CPOE use optional, encouraged or required? | Replication question |
| Topic Group: CPOE Not Currently in Place | |
| Are there plans to implement CPOE in your facility(ies)? If yes, timeframe for implementation? | CPOE has received support from agencies, coalitions and lawmakers. The question was asked to determine if this support translated to active plans to implement CPOE. |
| If there are no plans to implement CPOE reason(s)? | May provide insight regarding barriers to CPOE implementation. |

Table 3. Rationale for Survey Questions (continued).

| Survey Question | Rationale |
|---|---|
| Topic Group: CPOE Characteristics | |
| Internally developed CPOE system or vendor product? | Implementation and maintenance of vendor-developed systems is purported to be less costly and not as difficult as internally developed systems. |
| Is interactive decision support incorporated into the CPOE product? | Systems with DSS features have been shown to reduce errors and provide positive clinical practice changes. |
| Type of DSS incorporated?<br>Order checking<br>Order-relevant patient data display<br>Order relevant patient data capture<br>Rules based prompting and alerts within order entry<br>Rules based surveillance with alert outside of the entry | Determines the level of sophistication of currently employed DSS systems. |
| Do you utilize predefined order sets? | Predefined order sets have been shown to reduce order entry time as well as promote adherence to facility specific guidelines. |
| Does your CPOE system interact with other clinical systems? | CPOE gains functionality in systems that are integrated and allow data from other modules to be presented to the provider at the time of order entry. Of most importance is integration with other clinical systems. |
| Can orders be entered off-campus (remotely)? | Ability to enter orders offsite increases system availability and may increase the convenience of the CPOE system. |
| Topic Group: CPOE User Profile | |
| Please estimate the percentage range of physicians using computerized order entry. | Replication question |
| Percentage range of those that use CPOE who are: (a) residents/ interns, (b) housestaff / Fellows, (c) hospitalist/ employed MDs, (d) independent MDs, (e) nurse practitioners, (f) physician assistants, (g) other | An effort to determine if a particular specialty of healthcare professionals is more likely to use CPOE. |
| Please estimate the percentage range of orders entered by physicians using a computer. | Replication question |

Table 4. Rationale for Survey Questions (continued).

| Survey Question | Rationale |
|---|---|
| Percentage range of those that enter orders who are: (a) residents/ interns, (b) housestaff / Fellows, (c) hospitalist / employed MDs, (d) independent MDs, (e) nurse practitioners, (f) physician assistants, (g) other | An effort to determine if a particular specialty of healthcare professionals is more likely to use CPOE. |
| Topic Group: Goals/evaluation | |
| What were your goals for the CPOE system? Were they met? | Determination of what motivated the implementation of the CPOE system and whether the implementation met these goals. |
| Have you formally evaluated the CPOE system? | An effort to determine whether the CPOE system had been evaluated post-implementation |
| What benefit did CPOE provide that you never anticipated? | An attempt to identify heretofore undiscovered hidden benefits of CPOE implementation. |
| Topic Group: Demographics: | |
| Location of the your facility (a) rural (nonmetropolitan), (b) urban (central city), (c) suburban (outside central city) | All demographic questions (#18-20) were asked in an effort to determine CPOE implementation patterns. |
| Tax structure (a) for-profit, (b) non-profit ? | |
| Teaching or nonteaching facility? | |

## Data Collection Procedure

Initial contact with potential respondents and invitation to participate was made via telephone. The nature and purpose of the study were described and verification of qualification to serve as a study participant was assessed. Qualification to participate was determined by describing the questions that would be presented and asking the participant if they were knowledgeable regarding these aspects of their organizations information systems. Further qualification for inclusion was determined by the respondents ability to answer greater than 50% of the study questions. In cases where the respondent could not answer the required number of questions an alternate contact was requested. When

possible, interviews were conducted by the PI immediately. If the study participants were not available an alternate time was established for a follow up telephone call.

Study participants were given a verbal introductory statement and disclaimer and a description of the study (see APPENDIX C) prior to beginning the telephone interview. When voice mail was encountered, a brief informative statement was read which included a return telephone number (see APPENDIX D). In an effort to increase participation and reduce non-response bias, a total of three callbacks were attempted before the subject was removed from the study. Study participants were queried regarding their desire to receive a written copy of the study results.

## Data Analysis

Data were gathered, coded, and entered into a Microsoft Access database, checked for reliability and cleaned. Data were then imported into the statistical software program SPSS for Windows (release 10.0.7) and analyzed using descriptive statistics. Percentages and/or frequencies were used to describe characteristics of the respondents and non-respondents. Where information was available these characteristics were compared to US hospitals. Inferential statistics were used to detect differences between study respondents and non-respondents and CPOE and non-CPOE facilities. A priori alpha for determining significance was set at 0.05.

## Summary

A descriptive research design was employed in this study to collect data on a variety of variables regarding CPOE. The sample consisted of 316 respondent facilities

from the Ash et al. (1998) original sample database. A total of 189 contacted facilities chose to participate in the current study. These respondents were interviewed via the telephone using a telephone survey developed specifically for this study. Standard statistical analysis was used to identify differences between respondents and non-respondents, establish a participant profile, determine change in CPOE prevalence in the sample as well as CPOE usage, functionality, characteristics and goals. Percentages and frequencies described CPOE implementation planning for facilities that do not currently employ CPOE systems.

# CHAPTER 4

# FINDINGS

The results of the statistical analysis of the data are discussed in this chapter. Response rate is discussed. Respondents are compared to non-respondents and US hospitals for generalizability. Details of the sample characteristics are offered. Next, statistical results for the research questions are answered in turn. Frequencies and percentages are listed for sample data.

## Response Rate

The sample consisted of respondents to Ash et al. (1998) research. The original data set was a systematically selected random sample from the AHA guide. Of the 324 original postcard survey respondents, three were not in the 2002 AHA guide, one was duplicated in the original dataset, and four had closed in the interim; thus the sample consisted of 316 facilities. Telephone contact was attempted for these 316 facilities; of these, a total of 189 (60%) facilities participated in the study [respondents], 79 (25%) did not respond to messages left requesting participation, 44 (14%) declined to participate, and four (1%) facilities had closed.

Once contact was made with the facility, the Information Systems/Services (ISS) or Technology Support department was requested. When connected to this department, a clinical analyst was requested. The majority (90%) of the respondent interviewees reported directly to ISS (see Table 5). Analysis of the respondents' length of time in position reveals a/an; (1) average of five years, (2) minimum one month, (3) maximum

twenty-four years, and, (4) mode of four years. All respondents met the inclusion criteria by demonstrating the ability to answer at least fifty percent of the survey questions.

Table 5. Respondents – Title and Length of Time in Position.

| Job Title | Frequency | Percent |
|---|---|---|
| Chief Information Officer/Chief Operations Officer | 4 | 2.12 |
| Chief Financial Officer | 6 | 3.17 |
| Director/Asst. Dir. Information Systems/Services | 47 | 24.87 |
| IS/IT Manager/Supervisor | 30 | 15.87 |
| Clinical/Systems Analyst | 44 | 23.28 |
| Project Leader/Manager/Analyst | 9 | 4.76 |
| IS/IT Coordinator | 12 | 6.35 |
| Network/Database Administrator | 7 | 3.70 |
| IS Support | 5 | 2.65 |
| IS/IT, Other | 12 | 6.35 |
| Nursing/Physician IS Liaison | 2 | 1.06 |
| Director, Nursing | 3 | 1.59 |
| Manager, Other | 5 | 2.65 |
| Nursing, Other | 3 | 1.59 |
| Total | 189 | 100.00% |

The most common reason given for declining to participate was policy and/or procedures in place at the facility that specifically state staff members are not to participate in surveys of any kind, including research. When queried further about the reasons behind such policies and/or procedures, several interviewees replied that they were frequently asked by vendors to participate in surveys, thus causing an interruption in their workflow. Sample comments include; "I've wasted lots of time answering questions for vendors…it's really a waste [of my time]…they're just trying to sell me something" and "I don't have time…." Similar statements received from other respondents supported these comments. Several members of the participating respondent

group required multiple assurances that the primary investigator and/or her research was not in any way associated with a health information system vendor.

## Non-respondents

Statistical comparisons of key data elements were made to evaluate the representativeness of the sample (see Table 6 - Table 10 and Figure 5 - Figure 9). In an effort to determine if the sample was representative of US hospitals, these same data elements on US hospitals were gathered from *AHA Statistics* (2003) and the AHA website (American Hospital Association, 2002). These comparisons reveal a striking similarity on several key characteristics (bed size, control structure, membership/accreditation, approval codes) between study respondents, non-respondents, and, where applicable, US hospitals. Only aggregate data were available for US hospitals, which limited the ability to utilize inferential statistical analysis on these data.

Statistically, significant differences between respondents and non-respondents were determined using an independent *t*-test and the chi-squared test. A *p* value of less than 0.05 was considered statistically significant. For bed size, equal variance was assumed ($p$=0.06). A two sample *t*-test demonstrated no significant difference ($t_{258}$ = -1.63, $p$=0.105, two-tailed) between respondents and non-respondents in the bed size category. A graphical comparison (Figure 5) reveals the similarity of bed size between respondents, non-respondents and US community hospitals. Chi square analysis of census division also revealed a nonsignificant result ($X^2$=161.42, df= 172, $p$=0.71). Further analysis found no significant difference between respondents and non-

respondents on any tested variable (bedsize category, census division, membership/accreditation, approval codes, control structure).

Table 6. Comparison Bed Size Category Respondents: Non-respondents, US Community Hospitals

| | Respondents *n*=189 | | Non-respondents *n*=127 | | US Community hosp. *n*=4908 | |
|---|---|---|---|---|---|---|
| Bed Size | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| 6-24 | 5 | 2.65 | 2 | 1.57 | 281 | 5.73 |
| 25-49 | 34 | 17.99 | 18 | 14.17 | 916 | 18.66 |
| 50-99 | 46 | 24.34 | 25 | 19.69 | 1070 | 21.80 |
| 100-199 | 46 | 24.34 | 35 | 27.56 | 1218 | 24.82 |
| 200-299 | 24 | 12.70 | 21 | 16.54 | 635 | 12.94 |
| 300-399 | 15 | 7.94 | 10 | 7.87 | 348 | 7.09 |
| 400-499 | 9 | 4.76 | 4 | 3.15 | 191 | 3.89 |
| 500+ | 10 | 5.29 | 12 | 9.45 | 249 | 5.07 |
| Total | 189 | 100.00% | 127 | 100.00% | 4908 | 100.00% |

Figure 5. Graphical Comparison Bed Size: Respondents, Non-Respondents and US Community Hospitals.

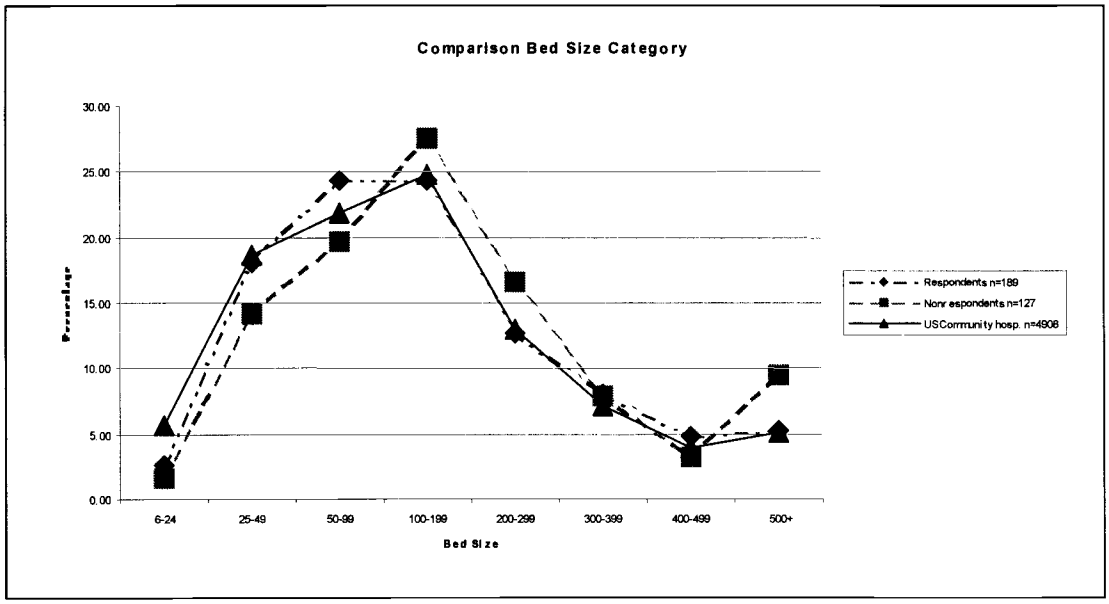


Table 7. Comparison Census Division (CDiv): Respondents, Non-respondents, US Community Hospitals.

| | Sample $n$=189 | | Non-respondents $n$=127 | | US Community Hsp. $n$=4908 | |
|---|---|---|---|---|---|---|
| CDiv[a] | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| 1 | 7 | 3.70 | 7 | 5.83 | 205 | 4.18 |
| 2 | 16 | 8.47 | 11 | 8.66 | 495 | 10.09 |
| 3 | 24 | 12.70 | 20 | 15.75 | 730 | 14.87 |
| 4 | 36 | 19.05 | 29 | 22.83 | 734 | 14.96 |
| 5 | 10 | 5.29 | 14 | 11.67 | 429 | 8.74 |
| 6 | 34 | 17.99 | 9 | 7.50 | 673 | 13.71 |
| 7 | 18 | 9.52 | 12 | 10.00 | 727 | 14.81 |
| 8 | 17 | 8.99 | 11 | 9.17 | 345 | 7.03 |
| 9 | 27 | 14.29 | 14 | 11.67 | 570 | 11.61 |
| Total | 189 | 100.00% | 127 | 100.00% | 4908 | 100.00% |

Note. [a]**Census Division (CDiv) Key**

1. **New England Division**: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
2. **Middle Atlantic Division**: New Jersey, New York, Pennsylvania
3. **South Atlantic Division**: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
4. **East North Central Division**: Illinois, Indiana, Michigan, Ohio, Wisconsin
5. **East South Central Division**: Alabama, Kentucky, Mississippi, Tennessee
6. **West North Central Division**: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
7. **West South Central Division**: Arkansas, Louisiana, Oklahoma/Indian Territory, Texas
8. **Mountain Division**: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
9. **Pacific Division**: Alaska, California, Hawaii, Oregon, Washington

Figure 6. Graphical Comparison Census Division: Respondents, Non-respondents, US Community Hospitals

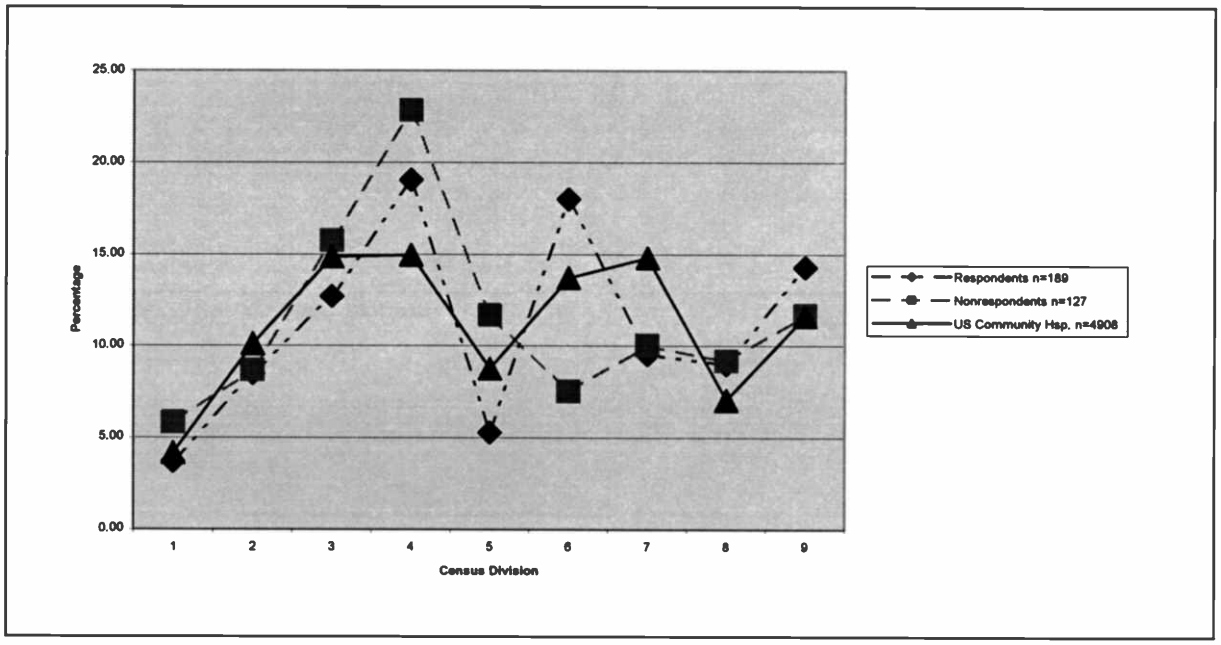



Table 8. Comparison Membership/Accreditation: Respondent and Non-respondent.

| | Respondents $n$=189[a] | | Non-respondents $n$=127[a] | |
|---|---|---|---|---|
| Membership/Accreditation | Frequency | Percent | Frequency | Percent |
| American Hospital Association (AHA) Membership | 143 | 75.66 | 91 | 71.65 |
| Commission on Accreditation of Rehabilitation Facilities (CARF) accreditation | 18 | 9.52 | 11 | 8.66 |
| American Osteopathic Association (AOA) accreditation | 4 | 2.12 | 2 | 1.57 |
| American Osteopathic Healthcare Association (AOHA) membership | 2 | 1.06 | 2 | 1.57 |
| Joint Commission on Accreditation of Healthcare Organizations (JCAHO) accreditation | 181 | 95.77 | 120 | 94.49 |

Note: [a]Facilities may have more than one response

Figure 7. Graphical Comparison Membership/Accreditation: Respondent and Non-respondent.

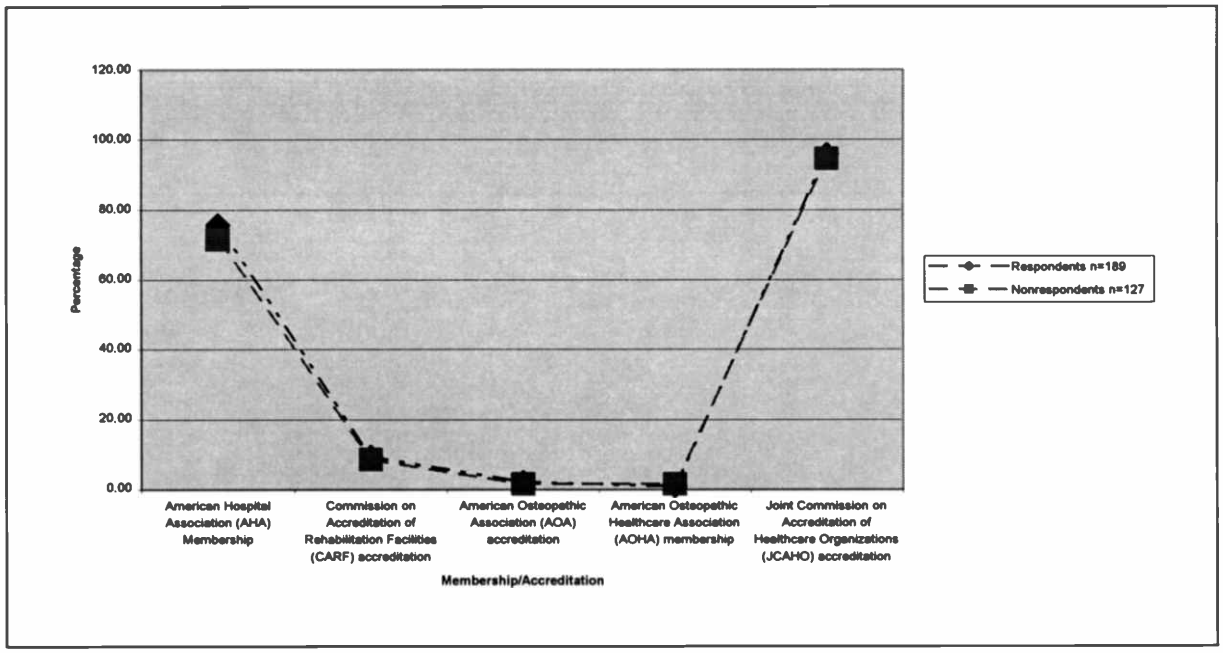


Table 9. Comparison Approval Codes: Respondents, Non-respondents.

| | Respondents $n$=189[b] | | Non-respondents $n$=127[b] | |
|---|---|---|---|---|
| Approval Codes[a] | Frequency | Percent | Frequency | Percent |
| Accreditation under the hospital program of the Joint Commission on Accreditation of Healthcare Organizations (March 2000) | 180 | 95.24% | 120 | 94.49% |
| Cancer program approved by American College of Surgeons (March 2000) | 57 | 30.16% | 37 | 29.13% |
| Approval to participate in residency training, by the Accreditation Council for Graduate Medical Education (March 2000). As of June 30, 1975, internship (formerly code 4) was included under residency, code 3 | 48 | 25.40% | 29 | 22.83% |
| Medical school affiliation, reported to the American Medical Association (March 2000) | 46 | 24.34% | 29 | 22.83% |
| Hospital-controlled professional nursing school, reported by National League for Nursing | 2 | 1.06% | 4 | 3.15% |
| Accreditation by Commission on Accreditation of Rehabilitation Facilities (March 2000) | 20 | 10.58% | 15 | 11.81% |
| Member of Council of Teaching Hospitals of the Association of American Medical Colleges (January 2000) | 10 | 5.29% | 15 | 11.81% |
| Hospitals contracting or participating in a Plan, reported by the Blue Cross and Blue Shield Association (April 2000) | 160 | 84.66% | 110 | 86.61% |
| Certified for participation in the Health Insurance for the Aged (Medicare) Program by the U.S. Department of Health and Human Services (January 2000) | 177 | 93.65% | 113 | 88.98% |
| Accreditation by American Osteopathic Association (April 2000) | 4 | 2.12% | 2 | 1.57% |
| Internship approved by American Osteopathic Association (April 2000) | 4 | 2.12% | 5 | 3.94% |
| Residency approved by American Osteopathic Association (April 2000) | 5 | 2.65% | 2 | 1.57% |
| Critical Access Hospitals (January 2000) | 0 | 100.00% | 0% | 100.00% |

Note. [a]Reported by approving bodies specified, as of the dates noted; [b]Facilities may have more than one response

Figure 8. Comparison Approval Codes: Respondents, Non-respondents.

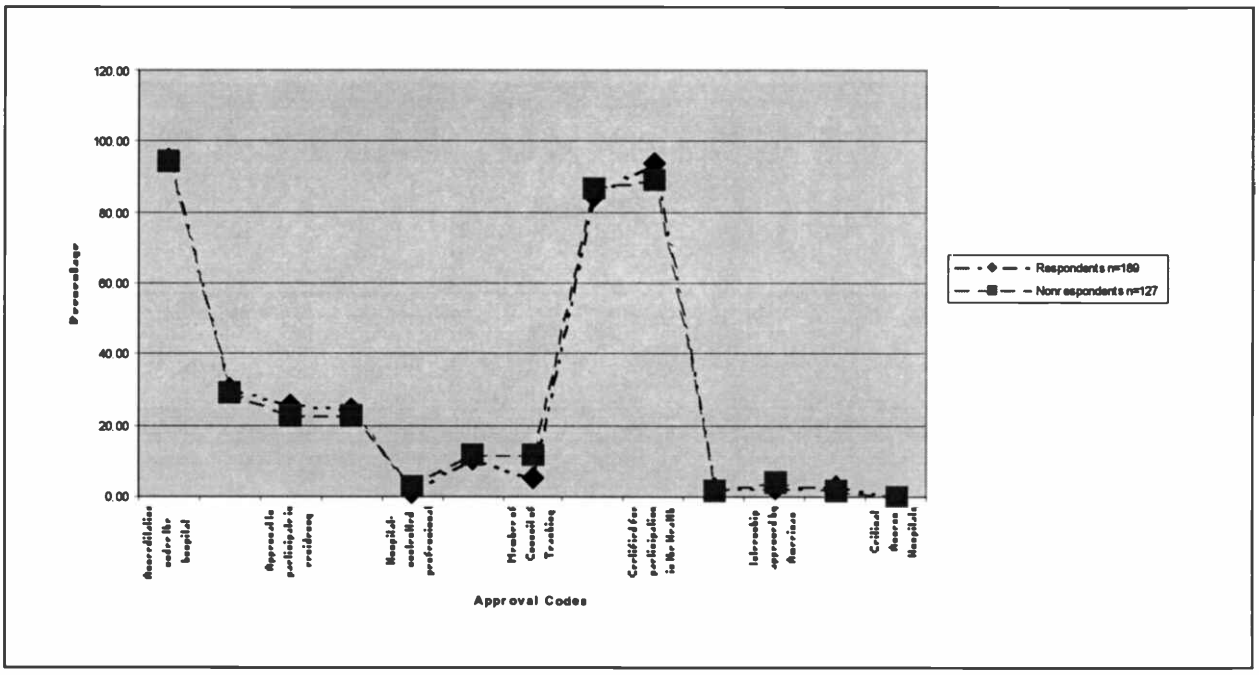
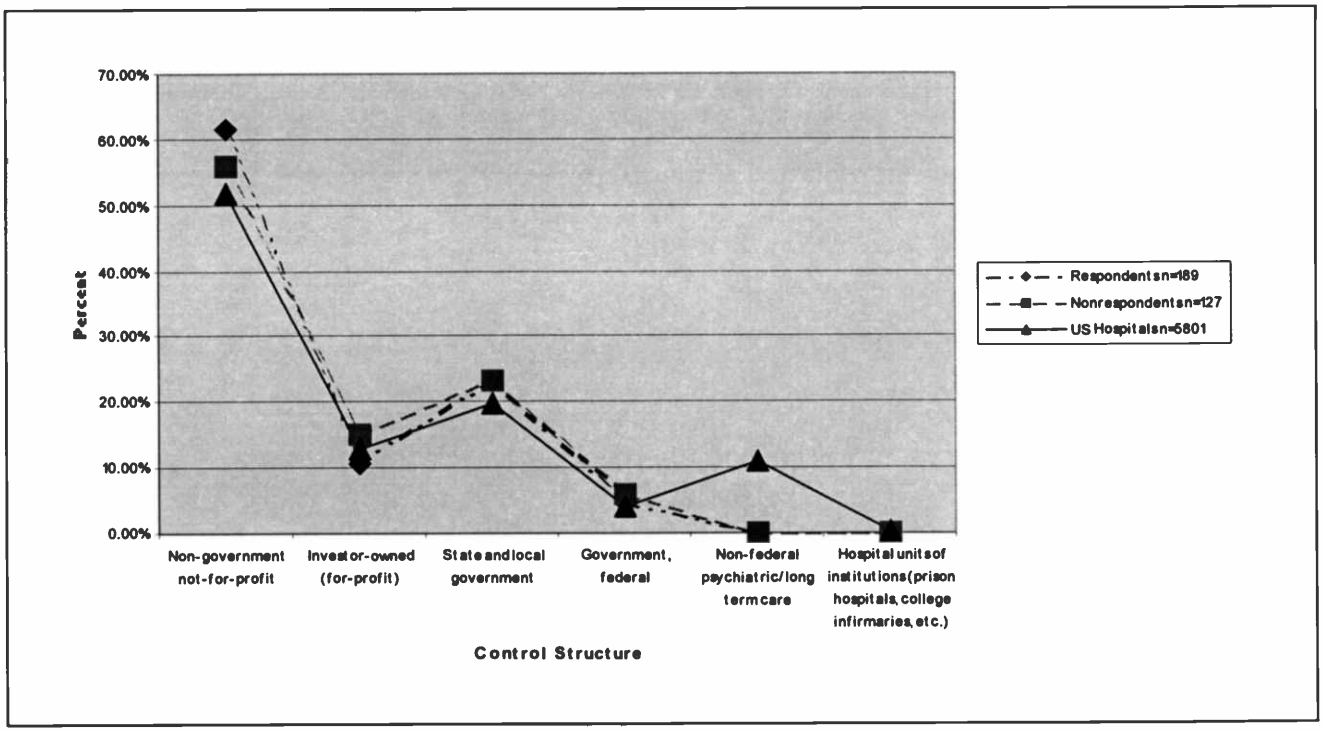



Table 10. Comparison Control Structure: Respondent, Non-respondent, US hospital.

| | Respondents *n*=189 | | Non-respondents *n*=127 | | US Hospitals *n*=5801 | |
|---|---|---|---|---|---|---|
| Control Structure | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| Non-government not-for-profit | 116 | 61.38 | 67 | 55.83 | 2998 | 51.68 |
| Investor-owned (for-profit) | 20 | 10.58 | 18 | 15.00 | 754 | 13.00 |
| State and local government | 44 | 23.28 | 28 | 23.33 | 1156 | 19.93 |
| Government, federal | 9 | 4.76 | 7 | 5.83 | 243 | 4.19 |
| Non-federal psychiatric/long term care | -- | -- | -- | -- | 631 | 10.88 |
| Hospital units of institutions (prison hospitals, college infirmaries, etc.) | -- | -- | -- | -- | 19 | 0.33 |
| Total | 189 | 100.00% | 120 | 100.00% | 5801 | 100.00% |

Figure 9. Comparison Control Structure: Respondent, Non-respondent, US hospital.




Participant profile

Location/Control/Bed Size/Membership

The 189 respondents represented facilities located in 44 states, both metropolitan and nonmetropolitan settings, as well as all United States Census Bureau divisions (see Table 11 and Table 12). All bed size categories defined by the AHA are represented by the sample though the majority of respondents (67%) are listed by the *AHA Guide* (2000) with a number of beds between 25 and 199. The sample also covers a wide range of facility ownership types (control structures) currently seen in the American healthcare environment: (a) 44 (23%) nonfederal government, (b) 116 (61%) non-profit, (c) 20 (11%) for-profit, (d) 6 (3%) federal government, and, (e) 3 (2%) Public Health Service

facilities. The sample is representative of the control structures reported by the AHA (American Hospital Association, 2002) for the 5801 US registered hospitals in 2001 (see Table 14).

Table 15 provides a more detailed categorization of the control structure as defined by AHA for the sample (see APPENDIX F for full list of applicable AHA definitions).

Table 11. Respondent Characteristics: Facility Location.

| Location $n$=189 | Frequency | Percent |
|---|---|---|
| Rural (nonmetropolitan) | 97 | 51.32% |
| Urban (central city) | 59 | 31.22% |
| Suburban (outside the central city) | 33 | 17.46% |
| Total | 189 | 100.00% |

Table 12. Respondent Characteristics: United States Census Divisions.

| | Respondents $n$=189 | | US Community Hospitals $n$=4908 | |
|---|---|---|---|---|
| Census Division | Freq. | Percent | Freq. | Percent |
| 1 New England Division - CT, ME, MA, NH, RI, VT | 7 | 3.70 | 205 | 4.18 |
| 2 Middle Atlantic Division - NJ, NY, PA | 16 | 8.47 | 495 | 10.09 |
| 3 South Atlantic Division - DE, DC, FL, GA, MD, NC, SC, VA, WV | 24 | 12.70 | 730 | 14.87 |
| 4 East North Central Division - IL, IN, MI, OH, WI | 36 | 19.05 | 734 | 14.96 |
| 5 East South Central Division - AL, KY, MS, TN | 10 | 5.29 | 429 | 8.74 |
| 6 West North Central Division - IA, KS, MN, MO, NE, ND, SD | 34 | 17.99 | 673 | 13.71 |
| 7 West South Central Division - AR, LA, OK, TX | 18 | 9.52 | 727 | 14.81 |
| 8 Mountain Division - AZ, CO, ID, MT, NV, NM, UT | 17 | 8.99 | 345 | 7.03 |
| 9 Pacific Division - AK, CA, HI, OR, WA | 27 | 14.29 | 570 | 11.61 |
| Total | 189 | 100.00% | 4908 | 100.00% |

Table 13. Respondent Characteristics – Facility size (staffed beds)

| | Respondents $n$=189 | | US Community Hospitals $n$=4908 | |
|---|---|---|---|---|
| Bed Size Category | Frequency | Percent | Frequency | Percent |
| 6-24 | 5 | 2.65 | 281 | 5.73 |
| 25-49 | 34 | 17.99 | 916 | 18.66 |
| 50-99 | 46 | 24.34 | 1070 | 21.80 |
| 100-199 | 46 | 24.34 | 1218 | 24.82 |
| 200-299 | 24 | 12.70 | 635 | 12.94 |
| 300-399 | 15 | 7.94 | 348 | 7.09 |
| 400-499 | 9 | 4.76 | 191 | 3.89 |
| 500+ | 10 | 5.29 | 249 | 5.07 |
| Total | 189 | 100.00% | 4908 | 100.00% |

Table 14. Respondent Characteristics: Comparison Control Structure Respondents vs. US Hospitals.

| | Respondents $n$=189 | | US Registered Hospitals[a] $n$=5801 | |
|---|---|---|---|---|
| Control Structure | Frequency | Percent | Frequency | Percent |
| Non-government not-for-profit | 116 | 61.38 | 2998 | 51.68 |
| Investor-owned (for-profit) | 20 | 10.58 | 754 | 13.00 |
| State and local government | 44 | 23.28 | 1156 | 19.93 |
| Government, federal | 9 | 4.76 | 243 | 4.19 |
| Non-federal psychiatric/long term care | -- | -- | 631 | 10.88 |
| Hospital units of institutions (prison hospitals, college infirmaries, etc.) | -- | -- | 19 | 0.33 |
| Total | 189 | 100.00% | 5801 | 100.00% |

Note. [a]See APPENDIX F for definition of registered hospital

Table 15. Respondent Characteristics – Control Structure.

| Control Structure $n$=189 | Frequency | Percent |
|---|---|---|
| 12 Government, nonfederal -- State | 9 | 4.76 |
| 13 Government, nonfederal -- County | 15 | 7.94 |
| 14 Government, nonfederal -- City | 1 | 0.53 |
| 16 Government, nonfederal -- Hospital district or authority | 19 | 10.05 |
| 21 Non-government not-for-profit -- Church operated | 20 | 10.58 |
| 23 Non-government not-for-profit -- Other | 96 | 50.79 |
| 32 Investor-owned (for-profit) -- Partnership | 1 | 0.53 |
| 33 Investor-owned (for-profit) -- Corporation | 19 | 10.05 |
| 41 Government, federal -- Air Force | 1 | 0.53 |
| 45 Government, federal -- Veterans Affairs | 5 | 2.65 |
| 47 Public Health Service Indian Service | 3 | 1.59 |
| Total | 189 | 100.00% |

The *AHA Guide* (2000) defines a system as "either a multihospital or a diversified single hospital system. A multihospital system is two or more hospitals owned, leased, sponsored, or contract managed by a central organization. Single, freestanding hospitals may be categorized as a system by bringing into membership three or more, and at least 25 percent, of their owned or leased non-hospital preacute or postacute health care organizations. System affiliation does not preclude network participation" (p. B2). The total number of US hospitals that reported membership in a health care system (*AHA Statistics*, 2003) was 2260 (46%). The sample showed a similar result with 97 (51%) reporting membership in a healthcare system (Table 16).

Table 16. Facility Characteristics – Membership in a Healthcare System.

| Membership $n$=189 | Frequency | Percent |
|---|---|---|
| Healthcare System | 97 | 51.32 |
| None | 92 | 48.68 |
| Total | 189 | 100.00% |

## Utilization/Service/Affiliation

The respondent facilities are further defined by their utilization statistics including average, (1) admissions, (2) census, (3) outpatient (OP) visits, (4) births, and, (5) personnel (see Table 17). As shown in Table 14, utilization, service and affiliation data reveal the following characteristics:

1. Annual admission rates of 9999 or less were specified by 78% (124) respondents that reported to the AHA in 1999 (see Table 18 - Table 21).
2. The most common physician models in both the respondent facilities and US community hospitals were:

a. Independent practice association (IPA) – An IPA is a legal entity that holds managed care contracts. The IPA then contracts with physicians, usually in solo practice, to provide care either on a fee-for-services or capitated basis (*AHA Guide*, 2000, p. A9).

b. Integrated salary model - Physicians are salaried by the hospital or another entity of a health system to provide medical services for primary care and specialty care (*AHA Guide,* 2000, p. A9).

c. Management service organization (MSO) – A corporation, owned by the hospital or a physician/hospital joint venture that provides management services to one or more medical group practices. The MSO purchases the tangible assets of the practices and leases them back as part of a full-service management agreement, under which the MSO employs all non-physician staff and provides all supplies/administrative systems for a fee (*AHA Guide*, 2000, p. A9-10).

d. Open physician-hospital organization (PHO) – A joint venture between the hospital and all members of the medical staff who wish to participate. The PHO can act as a unified agent in managed care contracting, own a managed care plan, own and operated ambulatory care centers or ancillary services projects, or physician members (*AHA Guide*, 2000, p. A10).

3. The *AHA Guide* (2000) reports that the majority of healthcare facilities provide general medical and surgical service (p. vi), which is reflected in the sample (see Table 20).
4. The majority of the respondent facilities are nonteaching entities – 64% ($n$=120) (see Table 21)

Table 17. Respondent Characteristics: Facility Utilization (Admissions, Census, Outpatient [OP] visits, births, full time equivalents [FTE])

| | | Average | | | | | |
|---|---|---|---|---|---|---|---|
| Bed Size | Frequency | Admissions | Census | OP visits | Births | Personnel (FTE) | Nonreporting[a] |
| 6-24 | 4 | 608.5 | 7 | 60274 | 85 | 97.25 | 1 |
| 25-49 | 28 | 1436.3 | 16.4 | 40956 | 157.2 | 206.1 | 6 |
| 50-99 | 37 | 2634.5 | 40.6 | 62339.1 | 322.3 | 356.5 | 9 |
| 100-199 | 40 | 5137.3 | 89.6 | 132773.4 | 669.4 | 672.8 | 6 |
| 200-299 | 22 | 9869.7 | 150.7 | 151851.1 | 1197.8 | 1143 | 2 |
| 300-399 | 13 | 14162.5 | 239.6 | 218948.2 | 1525.1 | 1753.3 | 2 |
| 400-499 | 6 | 18951.5 | 303.5 | 205456.2 | 2285.2 | 2381 | 3 |
| 500+ | 10 | 23867.2 | 553.9 | 477653.4 | 3566.4 | 3447.3 | 0 |

Note. [a]See APPENDIX F for definition of Nonreporting

Table 18. Admission Categorization: Respondents.

| Admissions $n$= 189 | Frequency | Percent |
|---|---|---|
| 1-249 | 1 | 0.63 |
| 250-499 | 3 | 1.88 |
| 500-1499 | 25 | 15.63 |
| 1500-2999 | 42 | 26.25 |
| 3000-4999 | 23 | 14.38 |
| 5000-9999 | 30 | 18.75 |
| 10000-14999 | 16 | 10.00 |
| 15000-19999 | 6 | 3.75 |
| 20000-29999 | 12 | 7.50 |
| 30000-39999 | 1 | 0.63 |
| 40000-49999 | 1 | 0.63 |
| Total | 160 | 100.00% |
| Nonreporting | 29 | |
| Grand Total | 189 | |

Table 19. Respondent Characteristics: Physician Models (Respondent, US Community Hospitals).

| | Respondents *n*=189 | | US Community Hospitals *n*=4908 | |
|---|---|---|---|---|
| Physician Models | Frequency | Percent | Frequency | Percent |
| Closed physician-hospital organization (PHO) | 22 | 11.64 | 316 | 6.44 |
| Equity model | 6 | 3.17 | 58 | 1.18 |
| Foundation | 9 | 4.76 | 212 | 4.32 |
| Group practice without walls | 7 | 3.70 | 250 | 5.09 |
| Independent practice association (IPA) | 32 | 16.93 | 824 | 16.79 |
| Integrated salary model | 54 | 28.57 | 1122 | 22.86 |
| Management service organization (MSO) | 29 | 15.34 | 545 | 11.10 |
| Open physician-hospital organization (PHO) | 41 | 21.69 | 849 | 17.30 |

Table 20. Respondent Characteristics: Type of Service.

| Type of Service *n*=189 | Frequency | Percent |
|---|---|---|
| General medical and surgical | 166 | 87.83 |
| Psychiatric | 14 | 7.41 |
| Rehabilitation | 1 | 0.53 |
| Other specialty | 4 | 2.12 |
| Children's general | 2 | 1.06 |
| Children's rehabilitation | 1 | 0.53 |
| Children's orthopedic | 1 | 0.53 |
| Total | 189 | 100.00% |

Table 21. Respondent Characteristics: Affiliation with Academic Institutions.

| Affiliation *n*=189 | Frequency | Percent |
|---|---|---|
| Teaching | 69 | 36.51 |
| Nonteaching | 120 | 63.49 |
| Total | 189 | 100.00% |

Context/Intervention/Client/Organization

Research Question One

How has CPOE prevalence in the Ash et al. (1998) surveyed healthcare facilities changed since the original survey? What is the availability of the systems in place?

What is the inducement of systems in place (a) optional, (b) encouraged, or, (3) required?

A comparison of CPOE prevalence data reveals an 18% decrease in the usage of these systems from the original Ash et al. (1998) research (see Table 22), with corresponding decreased availability. As yet unpublished preliminary research conducted by Ash and the POET team reveals a 12% reduction in CPOE systems in place since the 1998 study (J. Ash, personal communication, January 22, 2003). Interestingly, required order entry using CPOE systems was *increased.*

Table 22. Comparison Ash et al. (1998) and Respondents.

| Availability of CPOE - Ash et al. (1998) *n*=365 | | | Current Study Respondents *n*=189 | | |
|---|---|---|---|---|---|
| | Responses | % of Total Responses | Responses | % of Total Responses | Difference |
| CPOE in place | 117 | 32.05 | 26 | 13.76 | -18.30 |
| Complete availability | 54 | 14.80 | 13 | 6.88 | -7.92 |
| Partial availability | 63 | 17.30 | 13 | 6.88 | -10.42 |
| Not available | 241 | 66.00 | 163 | 86.24 | 20.24 |
| Unknown | 7 | 1.90 | 0 | 0.00 | -1.90 |
| Total | 365 | 100% | 189 | 100.00% | 0.00% |
| Inducement of CPOE | | | | | |
| Required | 18 | 4.90 | 15 | 7.94 | 3.04 |
| Encouraged | 31 | 8.50 | 4 | 2.12 | -6.38 |
| Optional | 82 | 22.50 | 7 | 3.70 | -18.80 |
| Not applicable | 234 | 64.10 | 163 | 86.24 | 22.14 |
| Total | 365 | 100.00% | 189 | 100.00% | 0.00% |

Research Question Two

How long has the CPOE system been in place (duration)?

Results indicate that 65% of the CPOE systems have been in place less than three years (see Table 23). An additional 23% have been in place less than ten years. Only one system had been in place greater than ten years.

Table 23. CPOE Duration.

| Years in Place | Frequency | Percent |
|---|---|---|
| 0 - 1 | 4 | 15.38 |
| 1.1 - 2 | 7 | 26.92 |
| 2.1 - 3 | 6 | 23.08 |
| 3.1 - 4 | 1 | 3.85 |
| 5.1 - 6 | 2 | 7.69 |
| 6.1 - 8 | 1 | 3.85 |
| 8.1 - 10 | 2 | 7.69 |
| 10.1 - 12 | 1 | 3.85 |
| Unknown | 2 | 7.69 |
| Total | 26 | 100.00% |

Research Question Three

What is the estimated percentage range of providers using CPOE (participation)?

Over 46% of the respondent facilities reported that 71-100% of their providers used CPOE to enter orders. Thirty percent or fewer providers used CPOE in 42% ($n$=11) of the respondent facilities (see Table 24 and Table 25). When compared to Ash et al.'s (1998) results, an increase in the number of providers using CPOE is evident.

Table 24. Comparison Percentage Range of Providers using CPOE (participation).

| | Ash et al. (1998) | | Current Study | | |
|---|---|---|---|---|---|
| Percentage Range[a] | Frequency | Percent | Frequency | Percent | Difference |
| <10% | 58 | 52.25 | 8 | 30.77 | -21.48 |
| 11-50% | 31 | 27.93 | 5 | 19.23 | -8.70 |
| 51-90% | 9 | 8.11 | 5 | 19.23 | 11.12 |
| >90% | 13 | 11.71 | 6 | 23.08 | 11.37 |
| Unknown | | 0.00 | 2 | 7.69 | 7.69 |
| | 111 | 100.00% | 26 | 100.00% | 0.00% |

Note. [a]Some overlap in percentage range categories

Table 25. Estimated Percentage Range of Providers using CPOE (participation).

| Percentage Range[a] *n*=26 | Frequency | Percent |
|---|---|---|
| 0-10 | 8 | 30.77 |
| 11-30% | 3 | 11.54 |
| 31-50 | 2 | 7.69 |
| 51-70 | 1 | 3.85 |
| 71-100 | 12 | 46.15 |
| Total | 26 | 100.00% |

Note. [a]Some overlap in percentage range categories

Research Question Four

What is the percentage range of orders entered by providers using the CPOE system (saturation)?

A comparison of Ash et al. (1998) and the current study reveals the percentage range of orders entered by providers via the CPOE system has increased. Ash et al. (1998) found 50% or fewer orders were entered by providers 80% of the time whereas the current study finds 42% in this category. Indeed, greater than 50% of orders were entered by providers using CPOE in 42% of the respondent facilities, versus 20% in 1998 (see Table 26).

Table 26. Percentage Range of Orders Entered by Providers (saturation).

| | Ash et al. (1998) *n*=111 | | Current Study *n*=26 | | |
|---|---|---|---|---|---|
| Percentage range of orders entered by providers[a] | Frequency | Percent | Frequency | Percent | Difference |
| 0-10 | 64 | 57.7 | 9 | 34.62 | -23.08 |
| 11-50 | 25 | 22.5 | 2 | 7.69 | -14.81 |
| 51-90 | 12 | 10.8 | 5 | 19.23 | 8.43 |
| 90-100 | 10 | 9.0 | 6 | 23.08 | 14.08 |
| unknown | -- | -- | 4 | 15.38 | 15.38 |
| Total | 111 | 100% | 26 | 100.00% | 0% |

Note. [a]Some overlap in percentage range categories

Research Question Five

What are the characteristics of the CPOE systems currently in place? The characteristics of interest include: (a) Type of product (internally developed vs. vendor product including name of software product), (b) Incorporation of decision support, (c) Types of decision support incorporated, (d) Use of predefined order sets, (e) Integration with other clinical systems, and, (f) Remote order entry capabilities

CPOE Software Product

A total of 26 respondents reported CPOE systems in place. Of this number, nine reported a federal control structure (five Veteran's Administration [VA], one US Air Force [USAF], and three Indian Health Service [IHS]). These federal facilities use clinical information systems which were internally developed by the Federal Government. In addition to the nine federal facilities (35% of total respondents with CPOE in place) with internally developed CPOE systems two (8%) investor-owned (for-profit) facilities reported internally developed systems. Various vendor CPOE products were utilized in the remaining 58% of facilities with CPOE in place (see Table 27). A

total of six facilities (23%) reported using the Meditech information system for CPOE. Of those six facilities, four used the Meditech Order Entry (OE) module, a module that was developed for order entry by intermediaries (basic order communication). The remaining two Meditech facilities employ Meditech's formal Physician Order Entry/Physician Order Management (POE/POM) CPOE product.

Table 27. CPOE Systems Utilized by Respondent Facilities.

| Vendor name *n*=26 | Software product | Frequency | Percent |
|---|---|---|---|
| Unknown | Action | 1 | 3.85 |
| $A^4$ Health | Healthmatics EMR | 1 | 3.85 |
| Eclipsys | TDS 7000 | 2 | 7.69 |
| Eclipsys | Sunrise Clinical Manager | 1 | 3.85 |
| McKesson/HBOC | Star/Apollo | 1 | 3.85 |
| Meditech | Physician Order (PO) Entry/PO Management | 2 | 7.69 |
| Meditech | Order Entry module | 4 | 15.38 |
| Siemens (used to be SMS) | Invision | 2 | 7.69 |
| Siemens (SMS) | Allegra | 1 | 3.85 |
| Internally Developed Systems | Subtotal | 15 | 57.69 |
| Composite Healthcare System (CHS) [USAF] | | 1 | 3.85 |
| Computerized Patient Record System (CPRS) [VA] | | 5 | 19.23 |
| Internally developed system | | 2 | 7.69 |
| Resident & Patient Management System (RPMS) [IHS] | | 3 | 11.54 |
| | Subtotal | 11 | 42.31 |
| | Total | 26 | 100.00% |

Decision Support

One of the features of CPOE systems that may have the greatest potential to positively impact patient safety is the application of decision support to the order entry process. Of the facilities with CPOE systems in place, 16 (62%) reported decision support in place, nine (35%) report no decision support, and, one (4%) did not know if decision support was available. The most common types of decision support were order

checking and order relevant patient data display. The two (8%) facilities that reported the more advanced DSS (DSS that alerts providers outside of order entry) both have internally developed HIS (control types, federal and investor-owned). See Table 28 for a full itemization of types of DSS in use in respondent CPOE systems.

Table 28. CPOE Characteristics: DSS.

| Decision Support System Type[a] *n*=26 | Frequency | Percent |
|---|---|---|
| Order checking – *checking of medication orders for drug interactions and contraindications (e.g. drug-drug and drug-allergy checking, minimum-maximum dose ranges, duplicate and therapeutic overlap checking.) | 13 | 50.00 |
| Order relevant patient data display – *automatic display of patient information relevant to the intervention being ordered (typically laboratory data to be reviewed before ordering a medication) | 13 | 50.00 |
| Order relevant patient data capture – *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) | 11 | 42.31 |
| Rules based prompting and alerts within order entry – *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) | 10 | 38.46 |
| Rules based surveillance with alert outside of order entry – *prompting and alerting to reconsider ordered interventions based on new information regarding patient characteristics or status, with notification/alert outside of electronic order entry | 2 | 7.69 |

Note. [a]Information in column 1 obtained from Metzger & Turisco, 2001, p. 13

Predefined Order Sets

Predefined order sets were utilized by the majority (81%) of the facilities with CPOE in place (see Table 29). One respondent stated that using predefined order sets "allows the physician to enter an entire set of orders in, like, 30 seconds...and they're all correct and complete." Also reported was the ability to use order sets to guide clinical practice and meet protocols.

Table 29. CPOE Characteristics: Utilization of Predefined Order Sets.

| Predefined order sets *n*=26 | Frequency | Percent |
|---|---|---|
| No | 3 | 11.54 |
| Yes | 21 | 80.77 |
| Unknown | 2 | 7.69 |
| Total | 26 | 100.00% |

Integration

The majority of CPOE systems in place interact via interfaces or as part of an integrated product with other clinical systems. This interaction is not surprising, because data from these modules directly affect clinical decision-making. Many respondent CPOE systems interacted with what are typically termed as "clinical systems" - nursing documentation, pharmacy, laboratory, radiology, respiratory and dietary (see Table 30). Fewer CPOE systems interacted with non-clinical or non-acute care environment types of modules. Facilities also reported that their CPOE systems interacted with other systems such as bar code administration, rehabilitation documentation, cardiology, gastrointestinal laboratory, and pulmonary function lab. One respondent reported that, though orders are entered via CPOE, all orders to ancillary departments are actually paper requisitions that automatically print at predefined locations (e.g., pharmacy medication orders will automatically print to pharmacy printers). Another respondent specified that, though CPOE is in use, it is only used for medication orders; all other orders are entered via handwritten orders and intermediaries.

Table 30. CPOE Characteristics: Interaction with other HIS Systems/Modules.

| | Interacts | | Unknown if Interacts | |
|---|---|---|---|---|
| Clinical System *n*=26 | Frequency | Percent | Frequency | Percent |
| Nursing documentation | 19 | 73.08 | 1 | 3.85 |
| Pharmacy | 19 | 73.08 | 0 | |
| Laboratory | 23 | 88.46 | 0 | |
| Radiology | 22 | 84.62 | 0 | |
| Respiratory | 16 | 61.54 | 4 | 15.38 |
| Monitoring | 6 | 23.08 | 1 | 3.85 |
| Dietary | 19 | 73.08 | 0 | |
| Environmental Services | 4 | 15.38 | 2 | 7.69 |
| Prescription writer | 5 | 19.23 | 1 | 3.85 |
| Outpatient Services (OPS) | 16 | 61.54 | 0 | |
| Practice management/clinics | 10 | 38.46 | 0 | |
| Community | 9 | 34.62 | 0 | |

Remote Order Entry

The majority (69%) of the responding facilities with CPOE in place reported the capability for clinicians to enter orders when off-campus via a remote connection to the hospital CPOE system (see Table 31). Two of the facilities that reported remote order entry capability also stated that it was not currently in use.

Table 31. CPOE Characteristics: Ability to Enter Orders Off-Campus (remotely).

| Remote Order Entry *n*=26 | | |
|---|---|---|
| Response | Frequency | Percent |
| No | 8 | 30.77 |
| Yes | 18 | 69.23 |
| Total | 26 | 100.00% |

Implementation Patterns

Research Question Six

Are there differences in the characteristics of facilities which employ CPOE and those which do not employ CPOE?

Facility Size (Staffed Beds)

Of the respondent facilities which employ CPOE 35% (9) are federal facilities. These federal facilities were part of the following bed size categories (staffed beds: frequency): (a) 25-49: four (16%) , (b) 100-199: two (8%), (c) 200-299: one (4%), (d) 300-399: one (4%), and, (e) 500+: one (4%). A total of 18 (69%) of the respondent facilities were 299 beds or fewer, though this is affected by the preponderance of federal facilities within these categories (see Table 32). A *t*-test revealed non-significant difference between CPOE and non-CPOE facilities on the variable bed size ($t_{28.97}$= –1.26, $p$=0.22, two-tailed, equal variance was not assumed).

Table 32. Comparison CPOE and non-CPOE Facilities: Bed Size.

| | Non-CPOE $n$=163 | | CPOE $n$= 26 | |
|---|---|---|---|---|
| Bed Size | Frequency | Percent | Frequency | Percent |
| 6-24 | 5 | 3.07 | 0 | 0.00 |
| 25-49 | 28 | 17.18 | 6 | 23.08 |
| 50-99 | 41 | 25.15 | 5 | 19.23 |
| 100-199 | 42 | 25.77 | 4 | 15.38 |
| 200-299 | 21 | 12.88 | 3 | 11.54 |
| 300-399 | 12 | 7.36 | 3 | 11.54 |
| 400-499 | 7 | 4.29 | 2 | 7.69 |
| 500+ | 7 | 4.29 | 3 | 11.54 |
| Total | 163 | 100.00% | 26 | 100.00% |

Admissions

The majority of respondent facilities reported admissions between 500 and 14,999. The non-CPOE facilities report 84% ($n$=116) admissions between 500 and 14,999, whereas the CPOE facilities report 91% ($n$=20) admissions in this range (see Table 33). T-test analysis (equal variances assumed) reveals a nonsignificant result ($t_{158}$= -0.14, $p$=0.89, two-tailed) between CPOE and non-CPOE facilities.

Table 33. Comparison CPOE and non-CPOE Facilities: Admissions.

| | Non-CPOE *n*=163 | | CPOE *n*=26 | |
|---|---|---|---|---|
| Admissions | Frequency | % of Subset | Frequency | % of Subset |
| 1-249 | 1 | 0.72 | 0 | 0 |
| 250-499 | 3 | 2.17 | 0 | 0 |
| 500-1499 | 23 | 16.67 | 2 | 9.09 |
| 1500-2999 | 37 | 26.81 | 5 | 22.73 |
| 3000-4999 | 17 | 12.32 | 6 | 27.27 |
| 5000-9999 | 26 | 18.84 | 4 | 18.18 |
| 10000-14999 | 13 | 9.42 | 3 | 13.64 |
| 15000-19999 | 6 | 4.35 | 0 | 0.00 |
| 20000-29999 | 10 | 7.25 | 2 | 9.09 |
| 30000-39999 | 1 | 0.72 | 0 | 0 |
| 40000-49999 | 1 | 0.72 | 0 | 0 |
| TOTAL | 138 | 100.00% | 22 | 100.00% |
| Nonreporting | 25 | | 4 | |

Membership in a Healthcare System,

The majority of the respondents with CPOE in place report membership in a healthcare system. These systems can be either "multihospital systems managed by a central organization or single hospitals systems that bring into membership three or more, and at least 25 percent, of their owned or leased non-hospital preacute and postacute health care organizations" (*AHA Guide*, 2000, p. B2). This differs from the non-CPOE respondents where membership in a healthcare system is not as prevalent (see Table 34). These frequencies and percentages are supported by significant chi square results ($X^2$=12.43, df= 1, $p$=0.001).

Table 34. Comparison CPOE and non-CPOE Facilities: Membership in a Healthcare System.

| | Non-CPOE *n*=163 | | CPOE *n*=26 | |
|---|---|---|---|---|
| Membership | Frequency | Percent | Frequency | Percent |
| Healthcare System | 74 | 45.40 | 21 | 80.77 |
| None | 64 | 39.26 | 1 | 3.85 |
| Nonreporting | 25 | 15.34 | 4 | 15.38 |
| Total | 163 | 100.00% | 26 | 100.00% |

Affiliation

The facilities with CPOE were more likely to be affiliated with a teaching institution than the non-CPOE facilities. Non-CPOE facilities report 33% (*n*=54) affiliation with teaching facilities whereas CPOE facilities report 58% (*n*=15) affiliation.

Facility Control Structure

The "non-government not-for-profit – other" was the most often reported control structure for both the non-CPOE facilities 53% (*n*=87) and the CPOE facilities 35% (*n*=9). Thirty-five percent (*n*=9) of the CPOE facilities reported some type of federal control structure (USAF, VA, IHS). There were no federal control structures among the non-CPOE facilities). These frequencies and percentages are reflected in the significant result of the chi square analysis ($X^2$=61.99, df= 10, *p*=0.00) for the control structure variable. A full comparison of non-CPOE vs. CPOE facilities is listed in Table 35.

Table 35. Comparison CPOE and non-CPOE Facilities: Control Structure.

| | Non-CPOE *n*=163 | | CPOE *n*=26 | |
|---|---|---|---|---|
| Control | Frequency | Percent | Frequency | Percent |
| Government, nonfederal -- State | 8 | 0.05 | 1 | 3.85 |
| Government, nonfederal -- County | 15 | 0.09 | 0 | 0.00 |
| Government, nonfederal -- City | 1 | 0.61 | 0 | 0.00 |
| Government, nonfederal -- Hospital district or authority | 18 | 0.00 | 1 | 3.85 |
| Non-government not-for-profit -- Church operated | 17 | 10.43 | 3 | 11.54 |
| Non-government not-for-profit -- Other | 87 | 53.37 | 9 | 34.62 |
| Investor-owned (for-profit) -- Partnership | 1 | 0.61 | 0 | 0.00 |
| Investor-owned (for-profit) -- Corporation | 16 | 9.82 | 3 | 11.54 |
| Government, federal -- Air Force [USAF] | 0 | 0.00 | 1 | 3.85 |
| Government, federal -- Veterans Affairs [VA] | 0 | 0.00 | 5 | 19.23 |
| Public Health Service Indian Service [IHS] | 0 | 0.00 | 3 | 11.54 |
| Total | 163 | 100.00% | 26 | 100.00% |

Service

The *AHA Guide* (2000) reports that the majority of healthcare facilities provide general medical and surgical service (p. vi), which is reflected in the comparison of CPOE and non-CPOE facilities (see Table 36). A Chi-squared test was nonsignificant ($X^2$=7.67, df= 6, $p$=0.26).

Table 36. Comparison CPOE and non-CPOE Facilities: Service.

| | Non-CPOE *n*=163 | | CPOE *n*=26 | |
|---|---|---|---|---|
| Service | Frequency | Percent | Frequency | Percent |
| General medical and surgical | 144 | 88.34 | 22 | 84.62 |
| Psychiatric | 13 | 7.98 | 1 | 3.85 |
| Rehabilitation | 1 | 0.61 | 0 | -- |
| Other specialty | 2 | 1.23 | 2 | 7.69 |
| Children's general | 1 | 0.61 | 1 | 3.85 |
| Children's rehabilitation | 1 | 0.61 | 0 | -- |
| Children's orthopedic | 1 | 0.61 | 0 | -- |
| Total | 163 | 100.00% | 26 | 100.00% |

Physician Models

The two most common physician models in both the non-CPOE and CPOE facilities were an integrated salary model (24% and 23% respectively) and PHO (18% and 19% respectively). The integrated salary mode is comprised of physicians who are salaried by the hospital or another entity of a health system to provide medical services. A PHO is joint venture between the hospital and all members of the medical staff who wish to participate (*AHA Guide*, 2000, p. A9). Both of these models represent a relationship between the facility and the physician that goes beyond an independent contract. Chi square analysis of the variable physician models revealed a nonsignificant result ($X^2$=1.78, df= 1, p=0.18).

Table 37. Comparison CPOE and non-CPOE Facilities: Physician Models.

| | Non-CPOE *n*=163 | | CPOE *n*=26 | |
|---|---|---|---|---|
| Physician Model[a] | Frequency[b] | Percent | Frequency[b] | Percent |
| 1 Closed physician-hospital organization (PHO) | 21 | 9.29 | 1 | 3.23 |
| 2 Equity model | 6 | 2.65 | 1 | 3.23 |
| 3 Foundation | 9 | 3.98 | 0 | -- |
| 4 Group practice without walls | 7 | 3.10 | 2 | 6.45 |
| 5 Independent practice association (IPA) | 32 | 14.16 | 5 | 16.13 |
| 6 Integrated salary model | 53 | 23.45 | 7 | 22.58 |
| 7 Management service organization (MSO) | 29 | 12.83 | 4 | 12.90 |
| 8 Open physician-hospital organization (PHO) | 40 | 17.70 | 6 | 19.35 |
| Nonreporting | 29 | 12.83 | 5 | 16.13 |

Note. [a]See APPENDIX F for definitions of physician models; [b]Facilities may have multiple responses

Location

Both CPOE and non-CPOE facilities reported a greater number of rural (nonmetropolitan) and urban (central city) locations than suburban (outside the central

city) locations. Non-CPOE facilities reported a greater number of rural locations (11% greater) and fewer urban locations (13% fewer) (see Table 38).

Table 38. Comparison CPOE and non-CPOE Facilities: Location.

| | Non-CPOE *n*=163 | | CPOE *n*=26 | |
|---|---|---|---|---|
| Location | Frequency | Percent | Frequency | Percent |
| Rural | 86 | 52.76 | 11 | 42.31 |
| Urban | 48 | 29.45 | 11 | 42.31 |
| Suburban | 29 | 17.79 | 4 | 15.38 |
| | 163 | 100.00% | 26 | 100.00% |

## Outcomes

### Research Question Seven

Were the goals for the CPOE system met?

The majority of the respondents (54%) reported that the goals for their CPOE system implementation have not been met (see Table 39). Respondents cited reduction in errors and increased efficiency amongst the goals that had been met. One facility cited their goal as "to implement it [CPOE]" and several cited goals of maximizing use of the CPOE system (see Table 40). In fact, some facilities have mandates that require 100% CPOE within a specific timeframe.

Table 39. Were CPOE Goals Met.

| Goals met? *n*=26 | Frequency | Percent |
|---|---|---|
| Yes | 9 | 34.62 |
| No | 14 | 53.85 |
| Unknown | 3 | 11.54 |
| Total | 26 | 100.00% |

Table 40. Examples of Reported Goals.

| |
|---|
| a) Standardization across facilities/network |
| b) Decrease reliance on paper chart |
| c) 100% orders entered into system |
| d) Greater utilization/participation |
| e) Reduction in errors |
| f) Reduce burden on nursing personnel and unit clerks |
| g) Increase efficiency |
| h) Benchmark outcomes |
| i) Establish practice guidelines |
| j) Correct billing issues |
| k) Increase reporting/data tracking |
| l) Increase system reliability |
| m) Make system more intuitive/increase ease of use |
| n) Increase legibility of MD orders |
| o) Increase patient safety |
| p) Increase availability of information for healthcare professionals |

Research Question Eight

Has the CPOE system been formally evaluated?

Formal evaluation of some type was performed in 66% (17) of the respondent facilities. Respondent comments indicate that these evaluations were comprised of various foci, but often evaluation of CPOE's impact on medication error reduction was named as a component of the evaluation process.

## Prospective CPOE Implementation

Research Question Nine

If CPOE is not currently in place are there plans to implement CPOE in your facility?

CPOE implementations may well be on the rise – 63% ($n$=119) of the respondent facilities who do not currently have CPOE in place reported plans to implement Almost 74% ($n$=88) of the respondents have active plans to implement CPOE within the next 5 years. Some facilities (8%) reported that there is no formal plan to implement CPOE but implementation was in varying stages of discussion. One facility reported they had purchased CPOE, but other clinical systems must be implemented prior to CPOE. Another facility purchased CPOE over 2 years ago but has been unable to resolve critical issues with the product, thus has not implemented it. Two facilities with plans to implement CPOE reported that they must update their infrastructure in order to properly accommodate CPOE (see Table 41).

Table 41. Time frame for CPOE Implementation.

| Timeframe (years) $n$=119 | Frequency | Percent |
|---|---|---|
| 0-1 | 28 | 23.53 |
| 1.1 - 2 | 35 | 29.41 |
| 2.1 - 3 | 10 | 8.40 |
| 3.1 - 5 | 15 | 12.61 |
| Unknown | 17 | 14.29 |
| No formal plans to implement | 10 | 8.40 |
| Purchased, other modules must be implemented first | 1 | 0.84 |
| Purchased, issues with product prevent implementation | 1 | 0.84 |
| Infrastructure must be updated prior to CPOE implementation | 2 | 1.68 |
| Total | 119 | 100.00% |

## Summary

The sample, interviewee, respondent and non-respondents characteristics were described. Comparisons were made between respondents, non-respondents and US hospitals (where applicable). These comparisons revealed striking similarities among these groups. A profile of the participants (respondents) was offered which revealed: (1)

51.32% rural facilities, (2) a preponderance of facilities in census divisions 3, 4, 6, 9, (3) the majority of the respondents have 299 or less staffed beds, (4) non-government not for profit was the most common control structure, (5) 51% report membership in a healthcare system, (6) 78% report admission rates of 9999 or less, (7) most common physician models IPA, integrated salary model, MSO, and PHO, (8) 88% provide general medical and surgical services. Research questions were answered in turn revealing (1) a decrease of 18% in CPOE usage since the original Ash et al. (1998) survey with corresponding reductions in availability, though interestingly, inducement was increased, (2) 46% of respondent CPOE facilities reported 71-100% of their providers use CPOE, (3) 65% reported the CPOE systems had been in place three years or less, (4) almost 63% of the respondents indicated they were actively planning to implement CPOE, (5) Meditech was the most commonly use CPOE system amongst the vendor products of the CPOE respondents, (6) 62% of the CPOE systems incorporated decision support, and (7) the majority of the CPOE systems utilized predefined order sets, interacted with other clinical systems, and, offered remote order entry capabilities. Characteristics of CPOE and non-CPOE facilities were examined and goal attainment statistics were presented. Finally, plans to implement CPOE are discussed.

# CHAPTER 5

# DISCUSSION

This chapter presents a discussion of the data analysis results and compares the data results to the findings of Ash, et al (1998). Where possible, results were compared to the literature. This chapter also discusses specific limitations to the study, implications, and suggests recommendations for further research. Results are discussed in relation to facilities with CPOE in place as this is the area of interest.

## Findings

The study replicated and extended Ash et al.'s (1998) research, which was conducted to determine the prevalence of CPOE systems in US hospitals. The sample was comprised of respondents to Ash et al.'s (1998) postcard survey delivered to a systematic sample of facilities listed in the *AHA Guide* (1997). The current study was conducted via telephone interviews which ranged in length from five minutes to two hours. Of the 316 facilities contacted, 189 chose to participate. All respondents met the inclusion criteria which required that the respondents to be able to answer 50% of the survey questions. If the initial respondent was unable to answer the questions, an alternate was requested. This occurred twice during the interview process.

## Sample

The sample was compared to both non-respondents and US hospitals (where applicable). The comparison found no significant difference between respondents and

non-respondents for the compared variables (1) bed size category, (2) census division, (3) membership accreditation, (4) approval codes, and, (5) control structure. Further, striking similarities were seen between respondents and US hospitals in the variables (1) bed size category, and, (2) control structure. Graphical displays show a greater variation between respondents and non-respondents and US hospitals for the variable census division. The high response rate combined with the similarity of the respondent group to both non-respondents and US community hospitals in terms of facility characteristics may indicate that nonresponse bias did not pose a serious problem in interpreting the results of this research.

## Context

### Prevalence

The research found 14% of surveyed facilities report CPOE in use. A comparison of these findings to the Ash et al. (1998) results demonstrates a decrease of 18% in CPOE prevalence. Unpublished preliminary research conducted by Ash and the POET team found a 12% reduction in CPOE systems in place since the 1998 study, corroborating the finding of the current study (J. Ash, personal communication, January 22, 2003). The result compares favorably with the Ringold et al. (1999) result where it was found that 13% of surveyed hospitals had an electronic medication order entry system. A recent Medical Records Institute (MRI) survey, however, indicates that 30% of healthcare organizations may have CPOE available (as cited in Versel, 2003). The MRI poll was taken "at its annual TEPR (Toward an Electronic Patient Record) conference last month,

an event geared toward the technically savvy" (Versel, 2003, paragraph 3), thus the results may be skewed.

One possible factor in this seeming decrease in CPOE prevalence between the Ash et al. results and the current research may have been a misinterpretation of the broad definition of CPOE by the original survey respondents. In fact, in telephone interviews conducted for the current research it was revealed that the CPOE definition as read to the respondents was often misunderstood to be order entry by an intermediary (nurse, clerk, etc.) of handwritten physician/provider orders. Some responding facilities also initially reported to the PI that they had CPOE in place when their system had the capability, but this capability was not necessarily *in use*. The ability to clarify the definition of the survey questions in the verbal interviews conducted for this research may account for the discrepancy in research results between the original research and the current research. There was no indication by the respondents that previously in place CPOE systems had been abandoned. Of the 189 interviewed respondents, only one reported that abandonment of a previously in-use CPOE system.

The minimal CPOE prevalence findings may soon change. There was significant interest in implementing CPOE systems reported by respondent facilities without CPOE in place. Sixty-three percent of these facilities reported plans to implement. Of these, almost 74% plan to implement CPOE within the next five years. This finding is supported by the HIMSS Leadership Survey (HIMSS, 2003) finding that lists CPOE as one of the top four application areas considered most important for healthcare clients. The Dorenfest survey asked a more specific question about CPOE implementation in

relation to support of patient safety initiatives, however, this survey also reports that over 37% of the respondent facilities planned to acquire a CPOE system (Dorenfest, 2003).

CPOE Implementation Patterns

Though a significant amount of research has been conducted on CPOE there are currently no published studies that describe the characteristics of facilities in relation to CPOE implementation. This study reveals a profile of the CPOE facility as most likely to be comprised of (1) a bed size of 299 or less, (2) an annual admission rate of between 500 and 14,999 (3) membership in a healthcare system, (4) affiliation with a teaching institution, (5) a control structure of non-government not-for-profit – other, (6) general medical and surgical service, (7) an integrated salary model for physicians, and (8) a rural or urban location (not suburban). The CPOE facilities represented every census division; however, the majority were equally distributed across census divisions 2, 4, 6, 8 and 9.

Human and Organizational Issues

Though human and organizational issues were not directly addressed by this research effort, many respondents discussed these aspects of CPOE. A formal qualitative review of the data has yet to be completed; however, themes were readily apparent from the comments received.

The respondents indicated that they felt that "older physicians" were not amenable to CPOE use. This was coupled with comments from several respondents that "young" physicians are requesting CPOE because many have experienced its use in their educational process. One respondent reported that the "'younger' physicians are gung

ho, but the older MDs are dragging their fingernails along the linoleum." The theme of "young" physicians versus "old" physicians is summed up by one respondent's comment, "I think that in about 15 years, when the 'young' physicians become the 'old' physicians, it [CPOE] will be accepted...."

Respondents spoke of their concern in implementing CPOE in facilities which employed independently contracted physicians/providers. For example, on respondent noted that "our MDs are independent contractors so we have no real say in what they do." Respondents indicated that facilities with employed MDs or residents would find it much easier to implement CPOE. The respondents felt that in these facilities administration and management had more control over physician practice.

Another commonly repeated barrier to implementation of CPOE was lack of physician interest. The two most common themes relating to this were: (1) required changes in workflow/practice with CPOE implementation, and (2) physician perceptions of increased time to enter orders with CPOE. One respondent summed this up in the following comment: "it's much easier to just hand the chart to the clerk [than to enter orders via CPOE]."

Safety

Respondents were aware of CPOE's potential to reduce errors and the current focus on patient safety initiatives in acute-care environments. Facilities with CPOE in place reported that medication error reduction was often a goal and was also often a

component of post-implementation evaluation. Additionally, the most commonly reported DSS types directly relate to medication error reduction.

## Client/Organization

### Availability

Availability of CPOE systems is defined as the extent to which the CPOE system can be accessed from all locations. Respondent facilities were evenly divided on this variable; 50% reported complete availability of the CPOE system and 50% reported partial availability. This result differs slightly from Ash et al.'s (1998) results in which 46% reported complete availability and 54% partial availability. The partial availability findings may reflect staged CPOE implementations, where the system is implemented in incremental steps (typically one or a small group of patient care units in a hospital setting). An additional component of availability is remote order entry capability of the CPOE system. The majority of the respondents reported remote order entry capability.

### Facility Demographics

Published research regarding CPOE includes several studies examining particular aspects of CPOE that were conducted in large and/or academic facilities (Ash, n.d.; Bates et al., 1998; Bates, 1999a; Bates, 1999b; Bates, Kuperman & Teich, 1994; Chin & Wallace, 1999; Lombardi, 2000; Tokarski, 2000). The current study found that 58% of the facilities with CPOE in place are affiliated with a teaching institution. This is supported by the finding that 50% of the respondents with CPOE reported in the AHA

annual survey the formal "approval to participate in residency training, by the Accreditation Council for Graduate Medical Education."

Additional demographics of note in respondent facilities with CPOE were: (1) bed size of 299 or less, (2) annual admission rate of between 500 and 14,999, (3) membership in a healthcare system, (4) a control structure of non-government not-for-profit – other, (6) provision of general medical and surgical service, (7) integrated salary model for physicians, and (8) location in a rural or urban area (not suburban).

Organizational Characteristics

Contrary to research indicating that large organizational size is a technology adoption facilitator (Grover & Goslar, 1993), this study found that 42% of respondent facilities with CPOE reported a bed size of 99 or less. This size is typically considered "small" in the healthcare vernacular. However, this may be tempered by the finding that the majority of the CPOE respondents were also a member of a healthcare system. The cumulative size of the system may be of more importance than each individual facility's size.

## Intervention

Participation is defined as the number of providers using CPOE at a particular facility. Dichotomous results were found with 42% of the respondents reporting 30% or fewer providers using CPOE and an additional 46% of the respondents reporting 71-100% using CPOE. Of those facilities that reported the percentage of orders entered by a provider (saturation), half reported 60% or less of the total orders were entered via the

CPOE system. The remaining 50% reported that 60-100% of the total orders were entered in this way. These results are interesting in light of the result for inducement (the extent CPOE usage is encouraged or required) that indicates that 58% of the respondents with CPOE in place require its use (a 3% increase from Ash et al. original research).

Most facilities reported using a vendor CPOE system. Though these "prepackaged" systems typically require some amount of customization, basic functionality is integrated into the system. Developing a CPOE system in-house could be both time and cost prohibitive in both development and maintenance phases. It appears that facilities in CPOE implementation planning stages will follow this trend. Several indicated intent to purchase a vendor developed product. One respondent summed the "build it or buy it" debate in this way (paraphrased), "We were developing a system in-house, but where we have one guy working on some aspect of this vendors have ten."

CPOE systems in place have several commonalities. The majority (65%) have been in place for three years or less. Sixty-two percent report decision support systems (DSS) in place. The most common types of DSS were order checking for drug interactions and contraindications and automatic display of patient information relevant to the intervention being ordered, though all DSS types defined by Metzger & Turisco (2001) were represented in the sample. Use of predefined order sets and remote order entry was common, also (81% and 69% respectively.

All CPOE systems interacted with other HIS systems/modules either via interfaces or as part of an integrated system. Not surprisingly CPOE systems were most likely to interact with clinical systems such as (1) nursing documentation (73%), (2)

pharmacy (73%), (3) laboratory (89%), (4) radiology (85%), (5) respiratory (62%), and, (6) dietary (73%). An additional 62% report CPOE integration with outpatient services systems/modules. Integration of clinical modules should provide increased functionality as it allows more patient specific information to be presented to the provider/clinician.

## Outcomes

### Goal attainment/evaluation

Respondents were asked to report their goals, as well as goal attainment, for the CPOE system. Patient safety initiatives were prominent in the goals reported, such as: (1) reduction in errors, (2) increased patient safety, (3) benchmarked outcomes, and (4) increased legibility. Fifty-four percent reported that the goals for their CPOE system had not been met.

It may be difficult to reach some of the stated goals (e.g., 100% of orders entered by a provider using the system). This goal may not take into consideration the workflow of the healthcare environment where some verbal orders are inevitable. Goals such as benchmarking outcomes, reduction of errors, and standardization across facilities will undoubtedly require the system to be in place for a period of time before they can be fully realized.

Formal evaluation of some type was performed in the CPOE system in 65% of the respondent facilities. Several respondents indicated continuing evaluative processes where when a goal was met another was developed. These evaluation processes may contribute to the betterment of future CPOE products.

## Conclusions

The study results indicate that CPOE does not enjoy extensive implementation. In fact, it appears that its prevalence has decreased. No indication was found that previously in place systems had been abandoned in large numbers. The ability to clarify definitions used in the survey may have contributed to the difference in the findings of the current research and Ash et al. (1998) findings. The low implementation rate is set to change soon, as 63% of the respondent facilities indicate active plans to implement CPOE in the next 5 years.

Implementation patterns uncovered in the current study support aspects of what can be extrapolated from current research (Ash, n.d.; Bates et al., 1998; Bates, 1999a; Bates, 1999b; Bates, Kuperman & Teich, 1994; Chin & Wallace, 1999; Lombardi, 2000; Tokarski, 2000). Frequently CPOE studies have been conducted in large, academic institutions. This is reflected in the sample's 58% affiliation with teaching institutions. However, both the bed size category and annual admission rates do not support the theory of large facilities comprising the majority CPOE implementations. These factors may well be affected, however, by the tendency for CPOE facilities to be a member of a healthcare system. The combined resources of the healthcare system may provide the benefits of a larger institution. CPOE implementations were represented in every census division, but they were more common in division (a) 2 (NJ, NY, PA), (b) 4 (IL, IN, MI, OH, WI), (c) 6 (IA, KS, MN, MO, NE, ND, SD), (d) 8 (AZ, CO, ID, MT, NV, NM, UT), and, (e) 9 (AK, CA, HI, OR WA). Of course, structural facility characteristics don't

illuminate the cultural and climate risks that have been associated with CPOE implementation.

CPOE systems currently in place have a greater availability and inducement than reported in the Ash et al. (1998) research. The respondents also indicated availability of remote order entry capabilities. Corresponding increases in saturation and participation indicate increased usage of the systems in place. The majority of the systems in use have been in place for three years or less. One can only speculate that patient safety initiatives or increasing maturity of CPOE systems are affecting their use.

Two aspects of CPOE that have gained attention as a means to reduce errors and impact clinical practice are the incorporation of DSS systems and integration with clinical systems (Bates et al., 1998; Bates, 1999a; Bates, 1999b; Bates, Kuperman & Teich, 1994; Chin & Wallace, 1999; Lombardi, 2000; Tokarski, 2000). Encouragingly, the majority of the sample reflects this with 62% reporting DSS and the majority reporting CPOE interaction with clinical systems. The majority of the facilities reported use of a vendor CPOE product, many of which have at least rudimentary DSS capabilities. Due to these features, the majority of the CPOE systems in place have the ability to positively affect patient care and safety.

Respondents were well aware of the patient safety initiatives and CPOE's role in advancing patient safety. However, comments received from several respondents indicated that they felt that CPOE systems were immature. Specifically, respondents cited the impact of CPOE on workflow and lack of understanding on the part of vendors about clinical workflow. These seem to echo the Drazen et al. (2000) assertion that we

continue to lack products that meet the needs of both the health care facility and the end-user.

It is promising that several respondents indicated continuing evaluative processes for in place CPOE systems. Unfortunately, 54% of the respondents indicated that the goals for their CPOE system had not been met. This may be due to the goals themselves or the need to have systems in place for a period of time before the goals can be measured or as yet unknown/unidentified issues.

## Limitations

The size of the sample prevents one from generalizing the study results to the population of healthcare facilities, particularly in the CPOE group. However, the similarities between the sample and US hospitals as reported in *AHA Statistics* (2003) may indicate that the sample may be more representative than one would have first considered. A larger, random, sample may provide a greater representation of the population. I think the similarity of the samples is so striking as to make generalizability very likely.

Nonresponses and refusals to participate may have served to bias the sample in ways that are not readily evident. Also, information collected in the study was of a self-report nature which, depending on the subject areas being queried, may be prone to some inaccuracy as a result of less than accurate recall, lack of information, or discomfort with disclosure. Though the information was not personal in nature, it is still possible that responses may have been self-edited.

## Implications

The healthcare IT market is driven by a number of internal and external factors including (1) medical error reduction, (2) HIPAA requirements/federal mandates, (3) state mandates, (4) Leapfrog group pressures, and, (5) profitability. CPOE has captured the attention of US healthcare systems as a means to impact these factors. The implementations of these systems will undoubtedly increase; particularly as the CPOE products improve.

The results of this study indicate that CPOE has not achieved widespread implementation. However, this is likely to change in the next five years as more facilities finish CPOE planning and begin the implementation phase. The scope and detail of each implementation will differ and range from enterprise-wide systems to single units/departments.

Though there has been significant interest in CPOE, little was known about the characteristics of systems in place or the facilities that employ them. This study describes both of these concepts. These descriptions may assist in determining the impact of legislative and regulatory initiatives on US hospitals as well as the potential of systems currently in use to impact these initiatives.

CPOE creates challenges and opportunities for medical practice. We must educate ourselves and our organizations about these systems and issues essential to the success of CPOE. At the same time we need to evaluate unmet patient needs as we redefine work processes in healthcare.

## Recommendations for future research

In this study, a profile for facilities that employ CPOE and the characteristics of these systems was developed. Due to the small sample size, the results may not be generalizable to the population. A replication of this study with a larger population would serve to verify its generalizability.

Another opportunity for research is determination of more specific functionality of CPOE systems. For example, (1) Are all types of orders entered into the CPOE system, (2) How are those orders communicated to ancillary services, (3) Does the system work as designed, (4) Is the design functional, and , (4) Does it provide the expected results? These questions will help identify how CPOE systems function, if the available products are immature, and, if they provide anticipated results.

Myths of CPOE may need to be dispelled. Though it was very commonly reported that "older" physicians and independently contracted physicians were unlikely to willingly use CPOE, there is no published research to support this assertion. More general assertions were lack of physician interest in CPOE. These commonly reported barriers to implementation deserve formal evaluation.

Respondents also frequently mentioned the need to upgrade existing infrastructure or implement non-CPOE clinical modules prior to CPOE implementation. Research is needed to determine infrastructure needs prior to CPOE implementation, or indeed, any perceived pre-implementation requirements. Evaluation of these factors relating to in place CPOE systems may also provide a requirements model.

# APPENDIX A

## ASH ET AL. (1998) RESULTS

**ABSTRACT**

*Objective: Determine the percent of U.S. hospitals where computerized physician order entry (POE) is available and the extent of its use.*

*Methods: A survey was sent to a systematic sample of 1,000 U.S. hospitals asking about availability of POE, whether usage is required, percent of physicians using it, and percent of orders entered by computer.*

*Results: About 66% do not have POE available. Of the 32.1% that have it completely or partially available, 4.9% require its usage, over half report usage by under 10% of physicians, and over half report that fewer than 10% of orders are entered this way. Analysis of comments showed that many hospitals have POE available for use by non-physicians only, but that they hope to offer it to physicians after careful planning.*

*Conclusion: Most U.S. hospitals have not yet implemented POE. Complete availability throughout the hospital is rare, very few require its use, low percentages of physicians are actual users, and low percentages of orders are entered this way. On a national basis, computerized order entry by physicians is not yet widespread.*

Table 42.Ash et al. (1998) Survey Results.

| **Availability of CPOE** | | |
|---|---|---|
| **Extent** | **Responses** | **% of Total Responses** |
| Complete availability | 54 | 14.8% |
| Partial availability | 63 | 17.3% |
| Not available | 241 | 66.0% |
| Unknown | 7 | 1.9% |
| | Inducement of CPOE | |
| Required | 18 | 4.9% |
| Encouraged | 31 | 8.5% |
| Optional | 82 | 22.5% |
| Not applicable | 234 | 64.1% |
| **Participation by Medical Staff (percent of staff using system)** | | |
| 10% or less | 58 | 52.2% |
| 11-50% | 31 | 28.0% |
| 51-90% | 9 | 8.1% |
| Over 90% | 13 | 11.7% |
| **Saturation of CPOE (percent of orders entered on system)** | | |
| 10% or less | 64 | 57.7% |
| 11-50% | 25 | 22.5% |
| 51-90% | 12 | 10.8% |
| Over 90% | 10 | 9.0% |

Table 43. Ash et al. (1998) Respondents.

| Respondents | |
|---|---|
| **Job Title/Category** | **Number** |
| CEO or President | 130 |
| Information Systems | 78 |
| Chief Information Officer | 26 |
| Vice President | 26 |
| M.D. | 21 |
| Admin. Asst./Officer | 17 |
| Chief Financial Officer | 9 |
| Nursing | 9 |
| Chief Operating Officer | 5 |
| Marketing, Public Affairs | 5 |
| Medical Staff Coordinator | 4 |
| Unspecified | 94 |
| Total Respondents | 364 |

# APPENDIX B

## HUMAN SUBJECTS APPROVAL

Human Subjects Protection Program
http://vpr2.admin.arizona.edu/human_subjects

THE UNIVERSITY OF
ARIZONA.
TUCSON ARIZONA

1350 N. Vine Avenue
P.O. Box 245137
Tucson, AZ 85724-5137
(520) 626-6721

10 July 2002

Vanessa Dorr, R.N., B.S.N.
Advisor: Judith Effken, Ph.D., R.N.
College of Nursing
PO BOX 210203

RE: **BSC B02.141** PREVALENCE AND CHARACTERISTICS OF COMPUTERIZED PROVIDER ORDER ENTRY SYSTEMS IN THE U.S.

Dear Ms. Dorr:

We received your research proposal as cited above. The procedures to be followed in this study pose no more than minimal risk to participating subjects. Regulations issued by the U.S. Department of Health and Human Services [45 CFR Part 46.110(b)] authorize approval of this type project through the expedited review procedures, with the condition(s) that subjects' anonymity be maintained. Although full Committee review is not required, a brief summary of the project procedures is submitted to the Committee for their endorsement and/or comment, if any, after administrative approval is granted. This project is approved effective **10 July 2002** for a period of one year.

The Human Subjects Committee (Institutional Review Board) of the University of Arizona has a current assurance of compliance, number M-1233, which is on file with the Department of Health and Human Services and covers this activity.

Approval is granted with the understanding that no further changes or additions will be made either to the procedures followed or to the consent form(s) used (copies of which we have on file) without the knowledge and approval of the Human Subjects Committee and your College or Departmental Review Committee. Any research related physical or psychological harm to any subject must also be reported to each committee.

A university policy requires that all signed subject consent forms be kept in a permanent file in an area designated for that purpose by the Department Head or comparable authority. This will assure their accessibility in the event that university officials require the information and the principal investigator is unavailable for some reason.

Sincerely yours,
Theodore J Glattke

Theodore J. Glattke, Ph.D.
Chair
Social and Behavioral Sciences Human Subjects Committee

TJG:tl
cc: Departmental/College Review Committee

# APPENDIX C

## INTRODUCTORY STATEMENT/DISCLAIMER SCRIPT

INTRODUCTORY STATEMENT/DISCLAIMER

Hello, my name is Vanessa Dorr. I'm a graduate student in Nursing Informatics at the University of Arizona College of Nursing and I'm conducting a survey of computerized provider order entry (CPOE) as part of my thesis research.

I'm calling to ask you to participate in a survey about CPOE at your facility. Your facility was identified as a participant in a previous study conducted by Joan Ash, Paul Gorman and William Hersch. The purpose of the survey is to determine the change in prevalence of CPOE in the four years since the original study as well as obtain information on the characteristics of systems in use. By responding to questions in the interview you will be giving your consent to participate. Individual responses and identities will remain confidential, and data will be used for research purposes only. Your assistance in this project would be greatly appreciated.

This telephone survey will take approximately 20 minutes of your time. May we arrange an interview appointment?

With your permission a tape recorder will be used. You may choose not to answer some or all of the questions. I will answer any questions that you may have regarding this study and you may opt to withdraw from the study at any time with no consequences whatsoever. The audiotape will be locked in a cabinet in a secure place. There are no known risks or direct benefits to your participation.

If you would like further information from me after this interview has concluded you may contact me at (520) XXX-XXXX. If you have questions concerning your rights as a research subject, you may call the Human Subject Committee office at (520) 626-6721. If you would like further information about CPOE you may visit the Oregon Health Sciences University (OHSU) website www.cpoe.org. If you have further comments you may address them to me, or to Joan Ash, Ph.D., M.L.S., via email at the CPOE website.

Do you agree to participate? Is it all right if I tape record your responses?

Thank you,

Vanessa Dorr, RN, BSN, MSN(c)

# APPENDIX D

## BRIEF INFORMATIVE STATEMENT (VOICE MAIL ENCOUNTER) SCRIPT

BRIEF INFORMATIVE STATEMENT (VOICEMAIL ENCOUNTER )

Hello, my name is Vanessa Dorr. I'm a graduate student in Nursing Informatics at the University of Arizona College of Nursing and I'm conducting a survey of computerized provider order entry (CPOE) as part of my thesis research. My research in a replication and extension of the research conducted by Joan Ash, Paul Gorman and William Hersh, which your facility participated in during 1998. [If applicable] I spoke with you on _____ and we set up an appointment at this time to complete the CPOE survey. If you would like to re/schedule please call me, my number is (520) XXX-XXXX. Alternatively, I will recontact you [date/time]. I'm looking forward to speaking with you! Thank you.

# APPENDIX E

## CPOE SURVEY INSTRUMENT

# CPOE SURVEY

**For the purpose of this survey, computerized provider order entry is defined as "direct entry of patient orders into a computer by the physician/provider, whether using a keyboard, light pen, voice entry, mouse or other device." This does not include entry by a surrogate or intermediary.**

## CPOE History

1. Is CPOE in place in your facility? Y ☐ N ☐ Not available at all (no system in place for use by physicians)
2. CPOE is:
   a. Partially available (offered in some form or some locations)
   b. Completely available (all orders can be entered in all locations)
   c. Was formerly available (system previously in place was abandoned)
      i. Please explain:
3. Length of time CPOE has been in place? _____
4. Are there plans to replace your current CPOE system? Y ☐ N ☐
   a. Timeframe? _____
   b. Reason: _____
5. CPOE use is:
   a. Optional (available, and there is no active program to increase use)
   b. Encouraged (program in place to encourage use; other options are discouraged)
   c. Required (no other option exists except in emergencies)

## If no CPOE in place:

6. Are there plans to implement CPOE in your facility(ies)? Y ☐ N ☐
   a. If yes, timeframe for implementation? _____
7. If no plans to implement CPOE what are the reason(s)?

## CPOE Characteristics

8. Internally developed ☐ or vendor product ☐ ?
   a. Vendor name? _____
   b. Software product? _____

9. Is interactive decision support incorporated into the CPOE product? (e.g. allergy alerts, drug interactions)
   Y ☐ N ☐

   a. Type(s) of DSS:

   Order checking ☐ order relevant patient data display ☐ order relevant patient data capture ☐

   rules based prompting and alerts within order entry ☐ rules based surveillance with alert outside of the entry ☐

10. Do you utilize predefined order sets? Y ☐ N ☐

11. Does the CPOE system interact with other clinical systems? Y ☐ N ☐

    a. Which modules/systems are integrated?

    | | | |
    |---|---|---|
    | nursing documentation ☐ | pharmacy ☐ | laboratory ☐ |
    | radiology ☐ | respiratory ☐ | monitoring ☐ |
    | dietary ☐ | environmental services ☐ | Prescription Writer ☐ |
    | OP Services ☐ | practice management/clinics ☐ | community ☐ |
    | Other ☐ | | |

    Anything else?

12. Can provider orders be entered off-campus (remotely)? Y ☐ N ☐

## CPOE User Profile

13. Please estimate the percentage range of providers using computerized order entry (for example 15-20%).
    _____%

    a. Percentage range of those that use CPOE who are:

| | | | | | |
|---|---|---|---|---|---|
| Residents/ Interns | | Housestaff / Fellows | | Hospitalist / employed MDs | |
| Independent MDs | | NP's | | PAs | |
| Other | | | | | |

14. Please estimate the percentage range of orders entered by providers using a computer
    _____%

    a. Percentage range of those that enter orders who are:

| | | | | | |
|---|---|---|---|---|---|
| Residents/ Interns | | Housestaff / Fellows | | Hospitalist / employed MDs | |
| Independent MDs | | NP's | | PAs | |
| Other | | | | | |

## Goals/evaluation

15. What were your goals for the CPOE system?
    _____

    a. Were they met? Y ☐ N ☐

16. Have you formally evaluated the CPOE system? Y ☐ N ☐

17. What benefit(s) did CPOE provide that you never anticipated?

## Demographics:

18. Is your facility - rural (nonmetropolitan) ☐ urban (central city) ☐ suburban (outside central city) ☐

19. Tax structure: for-profit ☐ non-profit ☐

20. Is your facility a: teaching hospital _____ nonteaching hospital _____

## Final questions:

21. Is there anything else you'd like to add?

22. If there are any follow-up questions may we re-contact you? Y ☐ N ☐

23. Source of information:
    a. Job title _____
    b. Length of time in position _____
    c. Length of time in IS / IT Services at this facility _____

24. Results: I am interested in receiving survey results. Please send them to:

| | |
|---|---|
| Name | |
| Title | |
| Mailing address | |
| | |
| City, State ZIP | |

If you would like more information about CPOE, please visit the Oregon Health Sciences University (OHSU) website WWW.CPOE.ORG. If you have further comments you may address them to Vanessa Dorr (520) XXX-XXXX, vdorr@nursing.arizona.edu, or to Joan Ash, Ph.D., M.L.S., via email at the CPOE website.

# APPENDIX F

## AMERICAN HOSPITAL ASSOCIATION (AHA) DEFINITIONS

**AHA Definitions (AHA Guide, 2000, p. A4)**

1. Beds – number of beds, cribs, and pediatric bassinets regularly maintained (set up and staffed for use) for inpatients as of the close of the reporting period.
2. Admissions – number of patients accepted for inpatient service during a 12-month period; does not include newborn
3. Census – average number of inpatients receiving care each day during the 12-month reporting period; does not include newborn.
4. Outpatient visits – a visit by a patient who is not lodged in the hospital while receiving medical, dental, or other services. Each appearance of an outpatient in each unit constitutes one visit regardless of the number of diagnostics and/or therapeutic treatments that a patient receives.
5. Births – Number of infants born in the hospital and accepted for service in a newborn infant bassinet during a 12-month period; excludes stillbirths.
6. Personnel – represents personnel situations as they existed at the end of the reporting period; includes full-time equivalents of part-time personnel. Full-time equivalents were calculated on the basis that two part-time persons equal one full-time person.

**Approval Codes (p. A4)**

7. Approval codes refer to approvals held by a hospital; they represent information supplied by various national approving and reporting bodies. For example, code A–1 indicates accreditation under one of the programs of the Joint Commission on

Accreditation of Healthcare Organizations –formal evidence that a hospital meets established standards for quality of patient care.

**Control Type (Classification codes) (p. A4)**

8. Indicate the type of organization that controls or operates the hospital and type of service.

**Nonreporting (p. A4)**

9. Nonreporting – indicated that the hospital was registered after the mailing of the 1999 Annual Survey, or, that the 1999 Annual Survey questionnaire for the hospital had not been received prior to publication.

**Registered Hospitals (p. A4)**

10. Registered hospitals are those hospitals that meet AHA's criteria for registration as a hospital facility. Registered hospitals include AHA member hospitals as well as nonmember hospitals. For a complete listing of the criteria used for registration, please see Registration Requirements for Hospitals. (AHA web http://www.hospitalconnect.com/aha/resource_center/content/registration%20requirements%20for%20hospitals.pdf)

**Physician Models (AHA Guide, 2000, p. A9-10)**

11. Closed physician hospital organization (PHO) – A PHO that restricts physician membership to those practitioners who meet criteria for cost effectiveness and/or high quality.

12. Equity model – Allows established practitioners to become shareholders in a professional corporation in exchange for tangible and intangible assets of their existing practices.
13. Foundation – A corporation, organized either as a hospital affiliate or subsidiary, which purchases both the tangible and intangible assets of one or more medical group practices. Physicians remain in a separate corporate entity but sign a professional services agreement with the foundation.
14. Group practice without walls – Hospital sponsors the formation of, or provides capital to physicians to establish, a "quasi" group to share administrative expenses while remaining independent practitioners.
15. Independent practice association (IPA) – An IPA is a legal entity that holds managed care contracts. The IPA then contracts with physicians, usually in solo practice, to provide care either on a fee-for-services or capitated basis.
16. Integrated salary model - Physicians are salaried by the hospital or another entity of a health system to provide medical services for primary care and specialty care.
17. Management service organization (MSO) – A corporation, owned by the hospital or a physician/hospital joint venture, that provides management services to one or more medical group practices. The MSO purchases the tangible assets of the practices and leases them back as part of a full-service management agreement, under which the MSO employs all non-physician staff and provides all supplies/administrative systems for a fee.

18. Open physician-hospital organization (PHO) – A joint venture between the hospital and all members of the medical staff who wish to participate. The PHO can act as a unified agent in managed care contracting, own a managed care plan, own and operated ambulatory care centers or ancillary services projects, or physician members.

References

Aarts, J., & Peel, V. (1999). Using a descriptive model of change when implementing large scale clinical information systems to identify priorities for further research. *International Journal Of Medical Informatics, 56*, 43-50.

Able, E. (2001). Perspectives: Physician order entry with Meditech. *Health Care Investment Visions Llc, 17*. Retrieved January 22, 2002, from http://www.hciv.com/knowledge/perspectives/01_01_meditech.html

*About Medication Errors* (2000). National Coordinating Council for Medication Error Reporting, & Prevention.. Retrieved August 21, 2002, from http://www.nccmerp.org Web site: http://www.nccmerp.org/aboutmederrors.htm

*AHA Guide 2000-2001 Edition.* (2000). Chicago, IL: Health Forum, LLC.

American Hospital Association. (2002). *Fast facts on U.S. hospitals from hospital statistics* (2001 Annual Survey). Chicago: Health Forum. Retrieved December 20, 2002, from www.aha.org Web site: http://www.hospitalconnect.com/aha/resource_center/fastfacts/fast_facts_US_hospitals.html

Ash, J.S. (1997). Factors affecting the diffusion of the computer-based patient record. *Proceedings AMIA Annual Symposium*, 682-6.

Ash, J. S. (n.d.). Perceptions of physician order entry: Results of a cross-site qualitative study. Retrieved February 22, 2003, from http://www.ohsu.edu/bicc-informatics/cpoe/perceptions.pdf

Ash, J.S., Gorman, P.N., & Hersh, W.R. (1998). Physician order-entry in U.S. hospitals. *Proceedings AMIA Annual Symposium*, 235-39.

Ash, J.S., Stavri, P.Z., & Kuperman, G.J. (2003) A consensus statement on considerations for a successful CPOE implementation. *Journal of the American Medical Informatics Association,* 10(3), 229-234

Baldwin, F. D. (2003). CPRs in the winner's circle. *Healthcare Informatics, 20*(5), 33-36.

Bates, D.W. (1999a). A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *American Journal of Medicine*, 106(2), 144-50.

Bates, D.W. (1999b). The impact of computerized physician order entry on medication error prevention. *Journal of the American Medical Informatics Association*, 6(4), 313-21.

Bates, D.W. (1999c). Frequency, consequences and prevention of adverse drug events. *Journal of Quality in Clinical Practice,* 19(1), 13-17.

Bates, D.W. (2000). Using information technology to reduce rates of medication errors in hospitals. *BMJ,* 320(7237), 788-91.

Bates, D.W., Cohen, M., Leape, L.L., Overhage, J.M., Shabot, M.M. & Sheridan. T. (2001). Reducing the frequency of errors in medicine using information technology. *Journal of the American Medical Informatics Association,* 8(4), 299-308.

Bates, D.W., Cullen, D.J., Laird, N., Petersen, L.A., Small, S.D., Servi, D., Laffel, G., Sweitzer, B.J., Shea, B.F. & Hallisey, R. (1995). Incidence of adverse drug events and potential adverse drug events: Implications for prevention. *JAMA*. 274(1), 29-34.

Bates, D.W., Kuperman, G., & Teich, J.M. (1994). Computerized physician order entry and quality of care. *Quality Management in Health Care,* 2(4), 18-27.

Bates, D.W., Leape, L.L., Cullen, D.J., Laird, L., Petersen, L.A., Teich, H.M., Burdick, E., Hickey, M., Kleefield, S., Shea, B., Vander Vliet, M.V. and Seger, D.L. (1998). Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA*, 280(1), 1311-1316.

Bates, D.W., Spell, N., Cullen, D.J., Burdick, E., Laird, N., Petersen, L.A., Small, S.D., Sweitzer, B.J. & Leape, L.L. (1997). The costs of adverse drug events in hospitalized patients: Adverse Drug Events Prevention Study Group. *JAMA*, 277(4), 307-11.

Bretschneider, S., & Wittmer, D. (1993). Organizational adoption of microcomputer technology: The role of sector. *Information Systems Research*, 4(1), pp 88-108.

Burris, B. H. (1998). Computerization of the workplace. *Annual Review Of Sociology, 24*, 141-157.

*California Senate Bill No. 1875, Chapter816* [Health and Safety Code]. Retrieved from http://info.sen.ca.gov/pub/99-00/bill/sen/sb_1851-1900/sb_1875_bill_20000928_chaptered.pdf, http://www.leginfo.ca.gov/bilinfo.html § 1 (2000).

Chin, H.L. & Wallace, P. (1999). Embedding guidelines into direct physician order entry; Simple methods, powerful results. *Proceedings AMIA Annual Symposium,* 221-25.

Classen, D.C., Pestotnik, S.L., Evans, R.S., Lloyd, J.F., & Burke, J.P. (1997). Adverse drug events in hospitalized patients. Excess length of stay, extra costs, and attributable mortality. *JAMA*, 277(4), 301-6.

*Computer Physician Order Entry* (2003). Retrieved April 3, 2003, from http://www.leapfroggroup.org/safety1.htm#CPOE

Doolan, D.F. & Bates, D.W. (2002). Computerized physician order entry systems in hospitals: mandates and incentives. *Technology & Medicine, 21I*(4), 180-8.

Dorenfest, S. (2003). Defining CPOE. *Advance For Health Information Executives, 7*(3), 33-36.

Drazen, E., Kilbridge, P., Metzger, J., & Turisco, F. (2000). A primer on physician order entry. Oakland, CA: *California HealthCare Foundation.*

Ebbesen, J., Buajordet, I., Erikssen, J., Brors, O., Hilberg, T., Svaar, H. et al. (2001). Drug-related deaths in a department of internal medicine. *Archives Of Internal Medicine, 161*(19), 2317-2323.

Evaluating CPOE systems: Key comparative criteria you'll need to consider. (2002). *Formulary, 37*(3), 157-58.

Evans, R.S., Classen, D.C., Pestotnik, S.L., Lundsgaarde, H.P., & Burke, J.P. (1994). Improving empiric antibiotic selection using computer decision support. *Archives of Internal Medicine,* 154(8), 878-84.

Evans, R.S., Pestotnik, S.L., Classen, D.C & Burke, J.P. (1999). Evaluation of a computer-assisted antibiotic-dose monitor. *Annals of Pharmacotherapy*, 33(10), 1026-1031.

Franz, C.R., & Robey, D. (1986). Organizational context, user involvement, and the usefulness of information systems. *Decision-Sciences,* 17(3), 329-56.

Grover V, Fiedler K, & Teng J. (1997). Empirical evidence on Swanson's tri-core model of information systems innovation. *Information-Systems-Research*, 8(3), 273-87.

Grover V, & Goslar MD. (1993). The initiation, adoption, and implementation of telecommunications technologies in US organizations. *Journal-of-Management-Information-Systems,* 10(1), 141-63.

Hayward, H. A., & Hofer, T. P. (2001). Estimating Hospital Deaths Due to Medical Errors: Preventability is in the Eye of the Reviewer. *JAMA,* 286(4), 415-420.

HIMSS. (2003, March 17). *14th Annual HIMSS Leadership Survey* (Vendor Chief Executive Officer Results). Superior Consultant, Inc.

Huag, P.J., Gardner, R.M., Tate, K.E., Evans, R.S., East, T.D., Kuperman, G., Pryor, T.A., Huff, S.M. & Warner, H.R. (1994). Decision support in medicine: Examples from the HELP system. *Computers and Biomedical Research*, 27(5), 396-418.

Hunt, D.L., Haynes, R.B., Hanna, S.E., Smith K. (1998). Effects of computer-based clinical decision support systems on physician performance and patient outcomes: A systematic review. *JAMA*, 280(15), 1339-1346.

Institute of Medicine. (2001). *Crossing the quality chasm: a new health system for the 21st century.* Washington, DC: National Academy Press.

Jha, A.K., Kuperman, G.J., Teich J.M., Leape, L., Shea, B., Rittenberg, E. Burdick, E., Seger, D.L., Vander Vliet M., and Bates, D.W. (1998). Identifying adverse drug events: development of a computer-based monitor and comparison with chart review and stimulated voluntary report. *Journal of the American Medical Informatics Association*, 5(3), 305-14.

Kaplan, B. (1997). Addressing organizational issues into the evaluation of medical systems. *Journal of the American Medical Informatics Association*, 4(2), 94-100.

Kaplan, B., Brennan, P.F., Dowling, A.F., Friedman, C.P., & Peel, V. (2001). Toward an informatics research agenda: Key people and organizational issues. *Journal of the American Medical Informatics Association*, 8(3), 235-41.

Kaushal, R., Bates, D.W., Landrigan, C., McKenna, K.J., Clapp, M.D., Federico, F., Goldmann, D.A. (2001). Medication errors and adverse drug events in pediatric inpatients. *JAMA*, 285(16), 2114-20.

Kilbridge, P. (2001). E-Prescribing. *California Healthcare Foundation.*

Kohn, L. T., Corrigan, J. M., & Donaldson, M. S. (Eds.). (1999). *To err is human building a safer health system.* Washington, DC: National Academy Press.

Kuperman, G.J., Teich, J.M., Gandhi, T.K. & Bates, D.W. (2001). Patient safety and computerized medication ordering at Brigham and Women's Hospital. *Journal on Quality Improvement*, 27(10), 509-521.

Leape, L.L. (2000). Preventing adverse drug events. Proceedings of understanding and preventing drug misadventures conference. [Online]. Available: http://www.ashp.org/public/proad/mederror/plea.html

Leape, L.L., Bates, D.W., Cullen, D.J., Cooper, J., Demonaco, H.J., Gallivan, T., Hallisey, R., Ives, J., Laird, N., & Laffel, G. (1995). Systems analysis of adverse drug events. ADE Prevention Study Group. *JAMA*, 274(1), 35-43.

Lehman JA. (1985-1986). Organizational size and information system sophistication. *Journal-of-Management-Information-Systems*, 2(3), 78-86.

Lombardi, T.P. (2000). Closing the loop – implementing quality improvement processes and advances in technology to decrease medication errors. [Online]. http://www.medscape.com/medscape/pharmacists/journal/2000/v01.n0.../mph7023.lomb-01.htm

Lorenzi, N.M., Riley, R.T., Blyth, A., Southon, G., & Dixon. B.J. (1997). Antecedents of the people and organizational aspects of medical informatics: Review of the literature. *Journal of the American Medical Informatics Association*, 4(2), 79-93.

Massaro, T.A. (1993). Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior. *Academic Medicine* 68,(1), 20-25.

McDonald, C.J., Hui, S.L., Smith, D.M., Tierney, W.M., Cohen, S.J., Weinberger, M. & McCabe, G.P. (1984). Reminders to physicians from an introspective computer medical record. A two-year randomized trial. *Annals of Internal Medicine*, 100(1), 130-38.

McDonald, C.J., Hui, S.L., & Tierney, W.M. (1992). Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. *MD Computing*, 9(5), 304-12.

Meadows, G., & Chaiken, B. P. (2002). Computerized Physician Order Entry: A Prescription for Patient Safety. *Nursing Economics, 20*(2), 76-87.

*Medical Error Reduction Act of 2000 (eHealth).* Senate Bill S.2038 and House of Representatives H.R. 3672. Feb 16, 2000. 106th Congress. Retrieved from http://thomas.loc.gov/cgi-bin/query/z?c107:S.2638

Metzger, J., Stablein, D. & Turisco, F. (2002). Clinical decision support finding the right path. Long Beach, CA: *First Consulting Group.*

Metzger, J., & Turisco, F. (2001). Computerized physician order entry: A look at the vendor marketplace and getting started. Long Beach, CA: *First Consulting Group.*

Mitchell, P.H., Ferketich, S., & Jennings, B.M. (1998) Quality health outcomes model. American Academy of Nursing Expert Panel on Quality Health Care. Image - the *Journal of Nursing Scholarship,* 30(1), 43-6.

Moran, D. W. (1998). Health information policy: on preparing for the next war. *Health Affairs, 17*(6), 9-22.

Morgan, G. (1997). Images of Organization. (2nd Ed.). Thousand Oaks, CA: *Sage Publications, Inc.*

Murff, H.J. & Kannry, J. (2001). Physician Satisfaction with two order entry systems. *Journal of the American Medical Informatics Association*, 8(5), 499-509.

Overhage, J.M., Perkins, S., Tierney, W.M., & McDonald (2001). Controlled trial of direct physician order entry: Effects on physicians' time utilization in ambulatory primary care internal medicine practices. *Journal of the American Medical Informatics Association*, 8(4), 361-371.

Overhage, J.M., Tierney, W.M., Zhou, A., & McDonald, C.J. (1997). A randomized trial of "corollary orders" to prevent errors of omission. *Journal of the American Medical Informatics Association*, 4(5), 364-75.

Perrow, C. (1983). The organizational context of human factors engineering. *Administrative Science Quarterly, 28*, 521-541.

Polit, D.F. & Hungler, B.P. (1999). Nursing research: Principles and methods. (6th ed.). Philadelphia, PA: *Lippincott Williams & Wilkins.*

Prus, S., sr. ed. (2003). 14th annual survey. *HIMSS News,* 12(2), 1-2.

Ringold, D.J., Santell, J.P., Schneider, P.H., & Arenberg, S. (1999). ASHP national survey of pharmacy practice in acute care settings: Prescribing and transcribing-1998. *American Journal of Health-System Pharmacy*, 56(2), 142-57.

Sado, A.S. (1999). Electronic medical record in the intensive care unit. *Critical Care Clinics*, 15(3), 499-522.

Salant, P., & Dillman, D.A. (1994). How to conduct your own survey. New York: *John Wiley & Sons, Inc.*

Schiff, G.D., & Rucker, T.D. (1998). Computerized prescribing: Building the electronic infrastructure for better medication usage. *JAMA*, 279(13), 1024-9.

Seger, D.L. (1999). Computerized POE: Changing roles for the clinical pharmacist. *Journal of the American Pharmaceutical Association*, 39(5), 710

Shane, R. (2002). Computerized Physician Order Entry: Challenges and Opportunities. *American Journal Of Health System Pharmacy, 59*, 286-288.

Shu, K. Boyle, D. Spurr, C., Horsky, J., Heiman, H., O'Connor, P., Lepore, J. & Bates, D.W. (2001). Comparison of time spent writing orders on paper with computerized physician order entry. *Proceedings IMIA annual symposium*, 1207-1211.

Sittig, D.F. & Stead, W.W. (1994). Computer-based physician order entry: The state of the art. *Journal of the American Medical Informatics Association*, 1(2), 108-123.

Skjei, E. (2002). Helping clinicians cope with CPOE systems. *CAP Today, 16(11)*. Retrieved December 28, 2002, from College of American Pathologists Web site: http://www.cap.org/captoday/archive/2002/cpoe_feature.html

Snyder-Halpern, R. (1999). Assessing health care setting readiness for point of care computerized clinical decision support system innovations. *Outcomes Management for Nursing Practice*, 3(3), 118-27.

SPSS for Windows, Rel. 10.0.0. 1999. Chicago: *SPSS Inc.*

Swanson EB. (1994). Information systems innovation among organizations. *Management-Science*, 40(9), 1069-92.

Teich, J.M., Merchia, P.R., Schmiz, J.L., Kuperman, G.J., Spurr, C.D. & Bates, D.W. (2000). Effects of computerized physician order entry on prescribing practices. *Archives of Internal Medicine*, 160(18), 2741-2747.

Tieman, J. (2001). Technology's Rip Van Winkles: Hospitals are waking up, slowly, to the need to embrace computers and automation. *Modern Healthcare*, 31(29), 30-2.

Tierney, W.M., Miller, M.E., Overhage, J.M., & McDonald, C.J. (1993). Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. *JAMA*, 269 (3), 379-83.

Tierney, W.M., Overhage, J.M. & McDonald, C.J. (1997). Demonstrating the effects of an IAIMS on health care quality and cost. *Journal of the American Medical Informatics Association*, 4(2), 41-46.

Tokarski, C (2000). Medical error-prevention strategies face barriers to acceptance [online]. *Agency for Healthcare Research and Quality*, Rockville, MD. Available: http://www.ahrq.gov/news/medscap2.htm

Valenta, A.L. & Wigger, U. (1997). Q-methodology: definition and application in health care informatics. *Journal of the American Medical Informatics Association*, 4(6), 501-509.

Versel, N. (2003, June 20). TEPR survey: CPOE may be more prevalent than thought. *Modern Physician*. Retrieved June 22, 2003 from http://www.cap.org/media/mediainfo/newsrel_snomedmri.htm

Weiner, M., Gress, T., Thiemann, D.R., Jenckes, M., Reel, S.L., Mandell, S.F. & Bass, E.B. (1999). Contrasting views of physician and nurses about an inpatient computer-based provider order-entry system. *Journal of the American Medical Informatics Association*, 6(3), 234-244.