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Influence of Organizational, Operational, Financial AndEnvironmental Factors on Hospitals' Adoption of Computerized Physician Order Entry Systems for Improving Patient Safety: A Resource Dependence Approach

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A dissertation paper submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

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Table of Contents

Page

Page

Page

List of Tables

Table Page

Table Page

List of Figures

Abstract

INFLUENCE OF ORGANIZATIONAL, OPERATIONAL, FINANCIAL AND ENVIRONMENTAL FACTORS ON HOSPITALS' ADOPTION OF COMPUTERIZED PHYSICIAN ORDER ENTRY SYSTEMS FOR IMPROVING PATIENT SAFETY: A RESOURCE DEPENDENCE APPROACH

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This study examines specific organizational, operational, financial and environmental characteristics to identify factors that are associated with increased likelihood of hospitals' CPOE adoption decision in six rollout regions of the Leapfrog initiatives.

Resource dependence theory provides theoretical basis for the study. The study is retrospective observational in design. Individual hospitals are the unit of analysis. The Leapfrog Group's 2002-survey collection serves the primary data source. Univariate statistical methods along with bivariate and ordinal logistic regression models are used to analyze the data. The models provided support for multiple hypotheses for both the

adoption and early adoption decisions of study hospitals. The operational characteristics of ownership, in-house physician staff, case mix index and the environmental characteristic of HMO penetration rate had a positive effect on management's adoption decisions. The operational characteristic excess capacity, the organizational characteristic community orientation, the financial characteristic of operating income per admission, and the environmental characteristic of number of HMO contracts had a significant negative effect on CPOE adoption decisions.

Chapter 1: INTRODUCTION

In 1999, the Institute of Medicine that is part of the National Academy of Sciences published the report "To Err is Human: Building a Safer Health System". The report cited numerous statistics to support the argument how much danger patients are in the present health care system. The report generated a vigorous debate in the scientific media with pro and con arguments about the merit of the paper as well as the implications for the various sub-systems of the larger health system investigated in the study. One of the sub-systems mentioned in the report was the in-hospital physician order entry setting, its present limitations and the consequentially high rate of medication errors.

The Institute of Medicine report also provoked the interest of large employers who earlier formed the Business Roundtable. The Business Roundtable members officially launched the Leapfrog Group in November 2000 to influence patient safety in hospitals through directed quality-based purchase of health care services.

The Leapfrog Group started issuing safety recommendations and began collecting compliance data in June 2001 by querying urban and suburban hospitals in six regions and now expanded to 23 regions. The 23 regions account for almost half of the US population and include 1,664 urban, suburban and rural hospitals. In April 2004, 61 percent (722) hospitals responded to the Leapfrog Hospital Quality and Safety Survey.

Leapfrog issues its safety recommendations only for urban hospitals at this time to avoid potential access problems for the rural population. Using experts of various fields the Leapfrog Group decided to initially focus on only three patient safety recommendations. The three safety practices that were recommended by Leapfrog are Computer Physician Order Entry, Evidence-Based Hospital Referral and Intensive Care Unit Physician Staffing. This study focuses only on the Computer Physician Order Entry (CPOE) system adoptions of hospitals.

The aim of the present research is an empirical analysis of the various internal and external factors associated with a hospital's adoption decision of the Leapfrog CPOE Initiative. The focus of this paper is to find factors that predict the likelihood of Leapfrog's CPOE recommendation adoption in hospitals.

Significance of the Study

Although there are numerous articles published about the Leapfrog Group in particular and an even larger number about CPOE in general, there are no studies from organizational structural, operational or environmental point of view of hospitals adopting Leapfrog's CPOE recommendation. In addition, the body of the evidence in the literature is ambiguous at best and non-supportive at worst for the Leapfrog safety recommendations. In spite of the lack of strong unequivocal evidence a number of hospitals adopted CPOE and an even larger number plans to adopt it.

The results of the study will enhance the current body of knowledge about hospitals' CPOE adoption. The study will provide a better understanding of the key internal and external factors associated with a hospital's CPOE adoption decision. The research will explore the relationship between hospitals' CPOE adoption and certain organizational structural, operational and environmental factors. The results of the study will benefit health care policy makers and hospital executives.

This paper is seeking to fill two gaps in the present body of knowledge. First, it will use an organizational theory framework to find organizational structural, operational and environmental factors that predict the likelihood of hospital's CPOE adoption. Second, this study is also relevant because Computerized Physician Order Entry as a specialized case of Information Technology could be considered as a "test case" in understanding organizational theory based factors of general Information Technology initiative adoption in a health care setting. The study will serve as a "template" for the organizational level analysis of other health care Information Technology adoption decisions.

Purpose of the Study

The purpose of this study is to provide better understanding of the organizational structural, operational characteristics and environmental conditions that are associated with hospitals' CPOE adoption. The objective of the study is to identify organizational structural, operational and environmental characteristics of hospitals that predict increased likelihood of hospital wide Computerized Physician Order Entry adoption as an instrument to improve quality of the health care delivery.

Scope of the Study

The study is focusing on patient safety as one aspect of the Institute of Medicine identified six dimensions of health care quality. In addition, the study's focus is on the hospital only as one player of the health care organizations that have documented patient safety problems. Out of the three measures that are recommended by the Leapfrog Group to improve patient safety the study only examines the use of Information Technology. Within Information Technology, all study questions will be related to the use of Computer Physician Order Entry (CPOE) systems. The study population includes only acute care hospitals in Metropolitan Statistical Areas that participated in the first two waves of Leapfrog rollouts.

The scope of the study is limited to identify organizational structural, operational and environmental predictors of increased likelihood of Computer Physician Order Entry system adoption in Metropolitan Statistical Area acute care hospitals as patient safety tool to comply with the Leapfrog Group's initiative.

Research Questions

The primary research question guiding the study is as follows:

- What are the organizational, operational and environmental factors that would characterize hospitals that adopt the Leapfrog Group's Computerized Physician Order Entry initiative?

While finding the answer to the primary research questions, the study will also answer the following sub-questions during hypothesis testing:

Are hospitals located in markets with higher HMO penetration rate more likely to adopt CPOE?

- Are hospitals located in markets with more HMO more likely to adopt CPOE?
- Are hospitals located in more competitive markets more likely to adopt CPOE?
- Are hospitals with excess capacity more likely to adopt CPOE?

- Are not-for-profit hospitals more likely to adopt CPOE than investor owned hospitals?
- Are hospitals that are more community oriented more likely to adopt CPOE?
- Are hospitals with salaried physician staff more likely to implement CPOE?
- Are larger bed size hospitals more likely to adopt CPOE?
- Are integrated delivery network or system member hospitals more likely to adopt CPOE?

Theoretical Approach

One of the problems with the present body of CPOE literature is that it lacks almost any theory based research framework. This study utilizes a single economic organizational level theory, the resource dependence theory. The resource dependence theory is well established as conceptual framework in health services research.

The resource dependence theory argues that organizations adapt to the continuously changing environment in order to survive. The theory also states that organizational survival is dependent on the acquisition of necessary resources from the environment. The level of adaptation is constrained by the availability of existing internal organizational resources and organizational structures.

The resource dependence theory claims that individual organizations when facing an uncertain environment are capable of changing in order to secure external resources from the environment. Such resources could come in many forms. The external resources may include tangible resources as patients, health care employees, technology or direct financial capital as the hospital's situation determines. The resources could also be intangible, for example reputation, legitimacy or goodwill. According to the resource dependence theory, various hospitals will have various levels of dependence on the particular resources that will result in various levels of motivation to change and adapt. This study is primarily focused on hospitals' efforts to secure the patient flow as tangible resource and considers legitimacy as an important intangible resource.

Methodology

The study uses a cross-sectional observational design that analyzes hospitals' CPOE adoption decision in the first two Leapfrog rollout regions in 2001 and 2002. The unit of analysis for the study is the individual non-federal acute care hospital. The sample population includes only Metropolitan Statistical Area hospitals in the particular Leapfrog rollout regions.

Data are drawn from multiple sources in order to provide the dependent and necessarily wide array of independent variables. The Leapfrog Group's 2003 hospital survey of initiative compliance is the primary data source for building dependent variables. Independent variables profiling hospitals' organizational structural and operational characteristics are developed by utilizing the 2003 American Hospital Association Annual Survey of Hospitals (AHA) database. Hospitals' environmental characteristics are drawn from the 2003 Edition of the Area Resource File (ARF).

Environmental factors will be analyzed at the Metropolitan Statistical Area level, as this is the level Leapfrog rolls out its recommendations. Hospital organizational structural and operational characteristics are analyzed at the individual hospital level.

The study is using descriptive statistics to gain insights into the variables' distribution. Univariate analysis will be utilized to further understanding of the variables.

In the main part of analysis, multivariate methods will be used to answer the research questions. Because of the binomial and multinomial categorical nature of the dependent variables logistic regression is applied to test the hypotheses.

Overview of Following Chapters

Chapter 2 provides a review of the literature of the Leapfrog initiatives and their support as reflected in the literature. The chapter also gives a short description of the Institute of Medicine reports that are relevant for the study and provided the necessary focus for the Business Roundtable employers to launch the Leapfrog Group. The second chapter also reviews the health care management innovation adoption literature. It shows our present understanding how management innovations are adopted in hospitals.

Chapter 3 presents the theoretical framework of the study. This chapter also describes the conceptual model and hypotheses for the research.

Chapter 4 provides the methodology. Data sources and research design are explained in detail. The chapter also describes the statistical methods utilized in the study and provides a short description of the statistics used to test the hypotheses.

Chapter 5 presents the results of the analyses. The findings of the univariate and multivariate methods are provided.

Chapter 6 explains the statistical findings of the previous chapter. It also interprets these results and draws conclusions. Implications for policy makers and hospital executives are presented along with recommendations for future research.

Chapter 2: LITERATURE REVIEW

This chapter provides a framing for the paper by utilizing a selected literature review on four topics that paints the necessary background of the study. First, a limited review shows the role of the Institute of Medicine reports as catalyzer for launching large employers' effort to influence health care quality. Second, the description of the Leapfrog Initiatives is provided. Next, in order to appreciate the problem that hospital managers is facing when the Leapfrog Initiative is rolled out in their area we should see what conclusions these managers would come to regarding the evidence base and implementation feasibility of a specific initiative. We will achieve this goal by reviewing the supporting and limiting evidence in the Leapfrog Initiatives' literature. Finally, a brief review of the history of management innovation adoption in health care is provided to show if the emergence of the Leapfrog movement is part of a pattern or a unique phenomenon

An increasing body of knowledge supports the notion that a gap exists between healthcare managerial decisions and research findings that optimally would serve as basis for these decisions (Walshe and Rundall, 2001). It seems that as opposed to the evidence-based clinical practice, that is more and more expected, evidence-based health care management lacks acceptance.

When managers face high degree of uncertainty in health care and causal ambiguity of an innovation they tend to make decisions based on their personal experience and "gut feelings" instead of strictly on the strength of research evidence (Walshe and Rundall, 2001 and Walston and Kimberly, 2001). Consequently, if there is ambiguity in the literature for the supporting evidence for various Leapfrog Initiatives it is expected that different managers would make different decisions facing the same ambiguous evidence among different organizational constraints and environmental characteristics. On the other hand, we can expect that if the evidence is unanimous either in a positive or negative way the managers would act more similar even among different organizational circumstances. That is if the literature paints a unanimously supportive picture for a specific Leapfrog Initiative then managers will feel more compelled to adopt it across the board and if the evidence is unanimously rejected in the literature the managers will generally less likely to adopt it. Individual managerial responses are more expected to vary if the literature paints a more ambiguous picture.

In case of feasibility of the initiative, managers should decide based on the literature and their experience if they think the initiative can be adopted in the specific hospital. This chapter will provide further details about the body of knowledge of innovation adoption in health care management after analyzing the evidence support and implementation readiness of the Leapfrog Initiatives. The literature review on Leapfrog measures and adoption of management innovations in health care will explain the study's focus on computerized physician order entry systems. It will also help in understanding other areas of the literature.

Institute of Medicine Reports

In 1999, the Institute of Medicine (IOM), a body formed by the National Academy of Sciences to "enlist distinguished members of the appropriate professions in the examination of policy matters pertaining to the health of the public," published a report titled "To Err Is Human: Building a Safer Health System" (Institute of Medicine, 1999). The IOM report Executive Summary contains the following two paragraphs:

> "Two large studies, one conducted in Colorado and Utah and the other in New York, found that adverse events occurred in 2.9 and 3.7 percent of hospitalizations, respectively. In Colorado and Utah hospitals, 8.8 percent of adverse events led to death, as compared with 13.6 percent in New York hospitals. In both of these studies, over half of these adverse events resulted from medical errors and could have been prevented.
>
> When extrapolated to the over 33.6 million admissions to U.S. hospitals in 1997, the results of the study in Colorado and Utah imply that at least 44,000 Americans die each year as a result of medical errors. The results of the New York study suggest the number may be as high as 98,000. Even when using the lower estimate, deaths due to medical errors exceed the number attributable to the 8th leading cause of death. More people die in a given year as a result of medical errors than from motor vehicle accidents (43,458), breast cancer (42,297), or AIDS (16,516)."

The above report is basically a follow-up, extended work of a previous report titled "Statement on Quality of Care" (Institute of Medicine, 1998). This study states:

> "In the 30 years from 1966 through 1995, more than 76, 000 journal articles were published from randomized controlled trials (as registered in the automated database MEDLINE). The first 5 years of that period contributed less than 1% of the total, whereas the last half decade contributed more than the previous 25 years combined. In the face of this avalanche of rigorous data on efficacy, our methods of training physicians and other clinicians and our systems of supporting them in the delivery of health care services have not kept pace."
>
> "A notable constraint to quality improvement is posed by the lack of an information infrastructure to support it in almost all health care delivery settings and the substantial investment needed to build such an infrastructure. Engaging clinicians actively and enthusiastically in quality improvement requires providing them with timely and detailed clinical information they believe and can use to judge quality of care."

The 1998 report also mentions the Utah's hospital study cited above in detail and continues on to claim that "the challenges may be stated simply: (1) to always provide effective care to those who could benefit from it, (2) to always refrain from providing inappropriate services, and (3) to eliminate all preventable complications.". The report brought up two important issues that served as recurring themes for later studies and industry activities: (1) preventable errors occur during health care delivery and (2) information technology can help in the prevention of these errors. Human knowledge alone can not keep pace with the amount of new information coming out in the medical field. The 1998 report cited the 76,000 randomized clinical trials over a 30 years period. Between 1996 and 2004 the medical field further added the results of more than 92,000 trials in eight years.

In early 2001, the Institute of Medicine published a third study "Crossing the Quality Chasm: A New Health System for the 21st Century" (Institute of Medicine, 2001). The report concludes that the health care system should aim to achieve six core quality needs:

1) Safe: avoiding injuries to patients from the care that is intended to help them.
2) Effective: providing services based on scientific knowledge to all who could benefit, and refraining from providing services to those not likely to benefit.
3) Patient-centered: providing care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions.

4) Timely: reducing waits and sometimes harmful delays for both those who receive and those who give care.
5) Efficient: avoiding waste, including waste of equipment, supplies, ideas, and energy.
6) Equitable: providing care that does not vary in quality because of personal characteristics such as gender, ethnicity, geographic location, and socioeconomic status.

The Leapfrog Initiatives

The Institute of Medicine reports stirred interest in the general public as well as a group of large employers who were already working together in the format of the Business Roundtable to gain influence over the quality and affordability of their purchased health care services. The IOM reports provided the necessary "focus" for the Business Roundtable employers where to start their market-based approach of influencing health care quality. The Business Roundtable members officially launched "The Leapfrog Group" in November 2000 and focused its efforts on achieving the first of the six Institute of Medicine health care quality goals, patient safety (The Leapfrog Group, 2004). Leapfrog is supported by the Business Roundtable, The Robert Wood Johnson Foundation and Leapfrog members. The membership grew from the original 60 organizations (National Healthcare Purchasing Institute, 2004) to more than 160 (as of October 2004). Currently the member organizations purchase health services for more than 34 million enrollees in more than $62 billion value (The Leapfrog Group, 2004, Piotrowski, 2003, Benko, 2002 and Greene, 2000). List of current Leapfrog members are presented in Appendix A. The Leapfrog Group began collecting data in June 2001 by querying urban and suburban hospitals in six regions and now expanded to 23 regions. The 23 regions account for almost half of the U.S. population and include 1,664 urban, suburban and rural hospitals. In April 2004, 61 percent (722) hospitals responded to the Leapfrog Hospital Quality and Safety Survey. Leapfrog issues its safety recommendations only for urban hospitals at this time to avoid potential access problems for the rural population (Weber, 2001). (Urban is defined as within the federal Metropolitan Statistical Areas (MSA) boundaries.)

The Leapfrog Group's mission is:

> "to trigger giant leaps forward in the safety, quality and affordability of health care by: Supporting informed healthcare decisions by those who use and pay for health care; and,
> Promoting high-value health care through incentives and rewards." (The Leapfrog Group, 2004)

The Leapfrog Group defined "purchasing principles" to focus on in order to achieve its mission. The original six purchasing principles crystallized to the current four (Smith, 2003). The first purchasing principle is to educate and inform enrollees about the safety, quality and affordability of health care and the importance of comparing the care health care providers give. Leapfrog presents the result of its surveys on its web site where the general public can compare the results from various hospitals freely. The group decided that the initial focus of this principle should be on Leapfrog safety measures. In the absence of outcome measures they turned to volume statistics and the presence (or absence) of specific process or structural measures. The second principle states the need for recognizing and rewarding health care providers for major advances in the safety, quality and affordability of their care. The basic idea behind this principle is that organizations delivering higher value should be rewarded. The rewards may be provided in the form of patient volume, price and public recognition. The third principle states that health plans should be held accountable for implementing the Leapfrog purchasing principles. The main idea is to intensify the incentives over time so the largest providers fully comply with all of the principles. The last principle encourages employers to use benefit consultants and brokers to drive systematic patient safety improvements in their health plans. The rationale for this principle is that large employers are relying on outside consultants to manage their health care benefits so these outside experts are uniquely situated to shape market behavior.

Using experts of various fields the Leapfrog Group decided to initially focus on only three patient safety recommendations (The Leapfrog Group, 2004). According to Leapfrog executives, four criteria were used to select (and later to refine and expand) the recommended patient safety practices (Eikel and Delbanco, 2003). First, the practice must have a significant evidence base to demonstrate its potential impact. We will analyze in this chapter how much Leapfrog succeeded or failed to adhere to the first self-stated criteria. Second, the practice must be easily understood and appreciated by the average consumer. It is very important to keep in mind this criteria when judging the Leapfrog initiative, so it is clear that Leapfrog never aspired to be a "perfect" academic approach to the health care problems but a very practical "down-to-earth" solution with a limited scope. Third, the practice must be ready to be implemented. Again, we will see that how well did Leapfrog adhere to its own third criteria. Last, implementation of the safety leap must be easily ascertainable by purchasers and consumers.

The three initial safety practices recommended by Leapfrog were Computer Physician Order Entry, Evidence-Based Hospital Referral and Intensive Care Unit Physician Staffing (Anonymous, 2004, Sarudi, 2001 and Weber, 2001). (In 2004 a fourth recommendation, the National Quality Forum's 27 Safe Practices were added (The Leapfrog Group, 2004).) In the following we will analyze how well did Leapfrog succeed to achieve its self-stated criteria that the practice must have a significant evidence base to demonstrate its potential impact by reviewing the selected literature. The review will also show us if hospital managers can gain an unambiguous account of the support of the specific initiative. Only the original three safety practices will be studied because the fourth recommendation is too recent to have substantial literature for pro or con arguments. In the last year some of the original safety practices were refined by Leapfrog. The result of this refinement is hardly reflected in the Leapfrog literature because the refinements occurred too recently. Neglecting the refinements has no effect on the validity of this study because the analyzed time frame of the managerial decisions is one between 2000 and 2003. Consequently, most of the review will focus on the original three Leapfrog recommendations in their original form. However, when new information either as a refinement or literature about the Leapfrog changes (pro or con) is available it will be mentioned.

The Leapfrog Group decided that initially they focus on the following three safety practices: Computer Physician Order Entry (CPOE), Evidence-Based Hospital Referral (EHR) and Intensive Care Unit Physician Staffing (IPS) (Berger and Kichak, 2004, Christian et al, 2003 and Manthous, 2004).

For Computer Physician Order Entry, the Leapfrog Group expects that hospitals that fulfill this standard will:

- require physicians to enter at least 75 percent of medication orders via computer linked to prescribing error prevention software.
- demonstrate that their CPOE system can intercept at least 50 percent of common serious prescribing errors, utilizing test cases and a testing protocol specified by the Institute for Safe Medication Practices (ISMP).
- require documented acknowledgement by the prescribing physician of the interception prior to any override.
- post the test case interception rate on a Leapfrog-designated web site. (Berger and Kichak, 2004 and The Leapfrog Group, 2004)

Since it will take many years until a significant number of hospitals meet this standard, the Leapfrog Group is using an interim approach in which hospitals are reporting their progress on the precursors of establishing CPOE.

For Evidence-Based Hospital Referral of the original Leapfrog initiative the recommendation was based on procedural volume thresholds. Hospitals to fulfill this standard needed to house a specific number of procedures annually in multiple categories:

- 500 coronary artery bypass graft (CABG) surgeries.
- 30 abdominal aortic aneurysm (AAA) repairs.
- 100 carotid endarterectomies (CEA).
- 7 esophagectomies [17].
- 400 coronary angioplasties.
- For delivery with expected birthweight less than 1,500 grams or gestational age less than 32 weeks a regional neonatal ICU with average daily census of at least 15 should be available.
- For delivery with prenatal diagnosis of major congenital anomalies a regional neonatal ICU with average daily census of at least 15 should be available (Weber, 2001).

Those hospitals that housed fewer procedures in any of the above categories were not recommended as a health care provider for that category. Effective January 2004 the Evidence-Based Hospital Referral category standards changed considerably (Birkmeyer and Dimick, 2004).

Because of the lack of accumulated experience (studies) with the new standards the literature can be reviewed only for the original standards. In addition, this paper focuses only on hospital management's innovation adoption between 2000 and 2003. Consequently, this paper analyzes the original standards only. When there is literature available for any of the new standards either pro or con they will be mentioned without further details provided. This will help us immensely on the long run to reduce the unwanted and unneeded number of pages of the paper to an acceptable level. The support and limitations of the various reports are discussed in the following pages.

Support and Limitation of IOM Report

First, we should clarify if the Institute of Medicine report (To Err Is Human) shows a real problem of medical errors on endemic proportions or the report "erred" and no problem exists where it says it does or that the problem's magnitude is smaller than claimed. The IOM report stated (see the quote in the beginning of the chapter) that at least 44,000 but potentially 98,000 Americans die annually because of medical errors (Institute of Medicine, 1999). This was the report that basically ignited the launch of the Leapfrog initiative (The Leapfrog Group, 2004). If the IOM report is flawed then the entire foundation of the Leapfrog "movement" is questionable. Both the Leapfrog Group's documents and the IOM report cite the same studies, Harvard Medical Practice and Utah-Colorado chart review studies from what the 44,000 and 98,000 medical error death statistics are derived (The Leapfrog Group, 2004, Brennan, Leape and Laird, 1991 and Leape et al, 1991 and Thomas et al, 1999).

Within a year as the IOM report was published serious criticism was raised if the IOM report was using the studies' statistics in the responsible way or that the original Harvard Medical Practice and the Utah-Colorado studies had correct statistical and study design approaches at all. McDonald et al pointed out that purely from a theoretical point of view the IOM report was wrong when implied that prevention of death from adverse drug events is a similar phenomenon (and can be statistically handled the same way) as prevention of death arising from motor vehicle accidents (McDonald, Weiner and Hui, 2000). Motor vehicle occupants do survive their ride if collisions are avoided. On the other hand, most patients admitted to hospitals have high disease burdens and high death risks even before they enter the hospital. McDonald points out that this baseline death risk has to be known and factored out before drawing conclusions about the real effect of adverse reactions on death rates. The biggest problem they found with the IOM cited studies that all were observational studies and were not designed to describe causal relationships.

Support and Limitation of CPOE Standard

One of the three Leapfrog patient safety recommendations consists the implementation of Computer Physician Order Entry (CPOE) system. These computer programs contain algorithms that alert health care providers to potentially harmful therapeutic decisions before orders are processed. The CPOE systems share the common features of automating the medication ordering process and ensure standardized, legible and complete orders. The installation of such systems is very costly and requires behavioral and organizational changes from the entire institution implementing them. The First Consulting Group found that it might cost as much as $7.9 million in the first year and $1.3 million in each subsequent year for an average 500-bed facility to implement CPOE (Morrissey, 2003).

The serious organizational and practice behavioral challenges can impede the system's implementation as well. One of the most known failure of CPOE implementation is linked to Cedars-Sinai Health System in Los Angeles that needed to remove its freshly installed CPOE system from use after an almost unanimous protest from the medical staff (Berger and Kichak, 2004 and Morrissey, 2003). One might assume that based on the various financial and organizational challenges that face the CPOE recommendation, it (of all three) should have the strongest adherence to the first self-stated Leapfrog criteria of Leapfrog standards, that is that the practice must have a significant evidence base to demonstrate its potential impact. Unfortunately, this does not seem to be the case. The evidence that CPOE reduces patient mortality is scant.

One of the latest systematic review of the CPOE literature was done by a group of researchers that included David Bates who is the most prominent supporter of CPOE as patient safety measure and is the CPOE Standard Expert Panel Chair at the Leapfrog Group (Kaushal, Shojania and Bates, 2003). They found only five articles that stood up to a rigorous review based on Owens' and Nease's normative analytic framework (Owens and Nease, 1997). Out of the five publications Bates was first author in two and co-author in one. All but one study was conducted in the same hospital, using the same CPOE system as subject of the study.

The five studies all used same or very similar definitions for medication errors, potential adverse drug events, adverse drug events and nonintercepted serious medication errors. Medication errors are errors in the process of ordering, transcribing, dispensing, administering or monitoring medications. Potential adverse drug events are medication errors with significant potential to harm a patient that may or may not actually reach a patient. Adverse drug events are injuries resulting from drug use and therefore constitute clinical outcomes. Adverse drug events associated with a medication error are considered preventable while those that are not associated with a medication error are considered non-preventable. Nonintercepted serious medication errors include nonintercepted potential adverse drug events and preventable adverse drug events (Kaushal, Shojania and Bates, 2003).

It is very important to understand the difference between the four definitions. In many studies and especially in the lay press these definitions are confounded. For example, if a study would find that a CPOE system (or any specific patient safety measure as study intervention) decreases adverse drug events then the CPOE implementation might at first look like a great leap in patient safety. However, if none of these adverse drug events is a preventable adverse drug event then the intervention has no value. All five studies found that the number of medication errors was reduced drastically after implementing CPOE. One study found 55 percent decrease in nonintercepted serious medication errors. Other study found 81 percent decrease in medication errors and 86 percent decrease in nonintercepted serious medication errors as a consequence of CPOE implementations.

These numbers are very impressive and are extensively quoted by the Leapfrog Group and various software vendors. However, the percentage decreases in the medication error (in general) and nonintercepted serious medication error categories do not mean too much. Medication errors can cause serious or non-serious, preventable or non-preventable adverse drug events and they can be potential or actual adverse drug events. Similarly there are multiple sub categories within the nonintercepted serious medication error category. The only category that is important from the point of view of practical patient safety is the category of preventable adverse drug events. Only two of the five studies reported the effect of CPOE on preventable adverse drug events. One found that preventable adverse drug events were reduced by 17 percent and the other found that adverse drug events were reduced by 60 percent. However, none of these findings were statistically significant because of the very low sample sizes (for example in one case preventable adverse drug events were reduced from five to two in the study period). None of the other three studies measured the rate of preventable adverse drug events.

The reality is that there is no statistically significant evidence from reliable study design that would support the claim that CPOE implementation reduces the number of preventable adverse drug events. In addition, researchers found that in the short term (first two years) after installing CPOE, the number of preventable adverse drug events actually increased (Berger and Kichak, 2004). This increase was the result of bugs in the CPOE systems. Still the fact is that there is no study that shows statistically significant decrease in preventable adverse drug events in the long term after the CPOE implementation. On the other hand, some studies document increase in preventable adverse drug events in the short term.

The study-based evidential support for the claim that CPOE system implementations are decreasing total health care cost is ambiguous at best. Similarly to patient care and outcome there is only a limited literature on cost and resource utilization after installation of CPOE systems. Particularly, studies are missing that would document savings after an organization wide CPOE implementation. One study showed 12.7 percent decrease in total hospital charges and decrease in length of stay by 0.89 day

(Berger and Kichak, 2004). However, the total cost per admission had no statistically significant change. The Leapfrog Group used the results of the first Bates' study as the basis for its theoretical calculations of decrease in health care costs after CPOE implementation (Berger and Kichak, 2004).

Leapfrog took the estimated 55 percent reduction in serious adverse drug events (although these were only potential adverse drug events and not actual preventable adverse drug events, see above) and calculated 522,000 adverse drug events as averted nationally. In next step they took the estimated $2,000 value of additional medical care cost per adverse drug event from a study of Classen et al and multiplied it with the 522,000 adverse drug events (Classen et al, 1997). Based on this calculation Leapfrog asserts that a nationwide implementation of hospital CPOE systems would save annually $1.1 billion for the U. S. health care system.

The above estimate is almost certainly incorrect because if the number of averted adverse drug events is 522,000 the preventable adverse drug events will be much less. Similarly, one might argue based on study evidence that the actual total cost savings are either none or only a marginal portion of the $2,000 that served as calculation base (Berger and Kichak, 2004). In addition, Leapfrog did not take into consideration the increased total workweek hours (as a consequence of CPOE implementation) that is estimated to be an additional five percent work time per physician (Shu et al, 2001). Based on the body of the literature of CPOE, one can safely argue that the CPOE standard of Leapfrog has ambiguous support both for reducing the number of preventable adverse drug events and total cost and resource utilization per admission.

Support and Limitation of EHR Standard

The second Leapfrog safety recommendation is called the Evidence-Based Hospital Referral (EHR). The name suggests that a very strong connection should exist between the safety recommendation and evidence supported by literature. Originally the recommendation was called Volume Standards and was later changed to Evidence-Based Hospital Referral (Birkmeyer, Finlayson and Birkmeyer, 2001). This recommendation was purely volume based no matter what the name implied and in large part even now it is still purely volume based. Birkmeyer et al estimated that potentially 2,581 lives would be saved by a nationwide implementation of the original standards (Birkmeyer, Finlayson and Birkmeyer, 2001).

The Leapfrog volume standards were developed based on the values published by Dudley et al. (Dudley, Johansen, Brand, Rennie and Milstein, 2000). They analyzed 72 articles addressing 40 procedures and diagnoses. At the end they could find "single best study" for only 11 diagnoses. The Leapfrog five procedures were among these 11. Birkmeyer converted the Dudley calculated Odds Ratios to relative risks using Zhang's and Yu's method (Zhang and Yu, 1998).

There are two strong assumptions in the Birkmeyer study. First is that the rest of the country looks like California (from the point of view of hospital volume cutoff points). Second that there was no change in the gap between the mortality risks of low versus high volume hospitals for the specific procedures during the last 13 years. None of these assumptions is necessarily correct.

The other potential problem of readily accepting the causal relationship between high volumes and lower mortality rates is that there is no proof for such causal relationship as Dudley himself states (Dudley, Johansen, Brand, Rennie and Milstein, 2000). Are HVHs better because of their volume ("practice makes perfect") or does the fact that certain hospitals have better outcomes lead them to receive more referrals? Interestingly, as Luft et al. found both explanations are valid and that the relative importance of the practice or referral explanation varies by diagnosis or procedure (Luft, Hunt and Maerki, 1987). Dudley acknowledges this limitation but neither Birkmeyer nor the Leapfrog Group does.

In a response to the Birkmeyer article, Russell lists five additional problems with the study (Russell, 2001). Some of the criticisms were actually explained by Birkmeyer in the paper. One point refers to the Khuri et al. article that reported the surgical volume outcome relationship from the VA health system (Khuri et al., 1999). In their study Khuri et al. found that in VHA hospitals, the procedure and surgical specialty volume in eight prevalent operations of intermediate complexity were not associated with risk-adjusted 30-day mortality rate from these operations. Out of the five Leapfrog volume standards, abdominal aortic aneurysm repair and carotid endarterectomy were included in the eight procedures studied. They conclude that volume of surgery in these operations should not be used as a surrogate for quality of surgical care. In a response to the Khuri paper, Birkmeyer noted that the lack of an association between hospital procedural volume and mortality in the VA might reflect structural and organizational factors unique to the VA system (Birkmeyer, 2000).

It is interesting that by arguing that structural and organizational factors may be responsible for the lack of volume-outcomes association, Birkmeyer more or less negate the argument of the Leapfrog initiative. In essence, as Birkmeyer assumes that a health care system (be it as limited in scope and as specific in function and structure as the VA system) is capable of performing procedures with same mortality rates in low and intermediate volume hospitals - and some of these rates are comparable to high volume private hospitals - then clearly the Leapfrog initiative of channeling patients to existing high volume hospitals is less desirable. The correct approach would be changing the underlying system and “lifting” the performance of substandard hospitals. Basically this is the conclusion what Dudley and Johansen reaches in their response to the original Birkmeyer report and Leapfrog initiative, too (Dudley and Johansen, 2001).

Rathore et al. evaluated the association between CABG volume and in-hospital mortality for recent (1998-2000) data (Rathore, Epstein, Volpp and Krumholz, 2004). They also found that for patients in medium volume hospitals the mortality risk was only 11 percent higher than in high volume facilities. The 11 percent is much less than the 27 percent what Leapfrog is using in its reports as risk reduction in high volume hospitals. They conclude that although they found volume-outcomes association for the CABG procedure the association was weaker than what Leapfrog and Birkmeyer suggest and because of the heterogeneity of quality within the various volume groups, volume is not an appropriate marker for CABG care quality.

In an other study Caprice et al. found that the Leapfrog criteria for volume standards were much higher for CABG and abdominal aortic aneurysm repair than what data would support and for carotid endarterectomies and esophagectomies no volume-outcomes association was found at all (Christian et al, 2003). The authors used the University Health System Consortium Clinical Database and reported evidence based volume standard of 250 procedures per year for CABG and 15 for abdominal aortic aneurysm, both numbers are half what Leapfrog is requiring.

There is evidence in the body of literature since 1979 when Luft and colleagues published their first volume-outcomes hypotheses that certain procedures have lower mortality risks in higher volume hospitals (Luft, Bunker and Enthoven, 1979). However, even now more than two decades later there remain many unanswered questions. One issue that comes up stubbornly in most of the studies that find volume-outcomes association is that there is a considerable overlap in performance between high-volume and low-volume providers (Shahian and Normand, 2003).

Recent studies indicate that the impact of volume might decrease over time as procedures mature (Shahian and Normand, 2003 and Rathore, Epstein, Volpp and Krumholz, 2004). Also, there is a high level of ambiguity in the literature regarding the "correct" cut-off point for volume for separating low-volume and high-volume hospitals. Shahian et al. analyzed the same data set what Dudley used to determine the volume cut-off points for CABG, which is the basis for the Leapfrog recommendations, too. They found that the most significant mortality change point occurred at a much lower volume of less than 300 procedures (Shahian and Normand, 2003 and Dudley, Johansen, Brand, Rennie and Milstein, 2000).

Support and Limitation of IPS Standard

The third Leapfrog patient safety recommendations is called ICU Physician Staffing (IPS) standard. Manthous provided a thorough recent critique of the state of literature support of Leapfrog's IPS initiative and for each of the IPS subcategories (Manthous, 2004).

The first subset of the IPS recommendations requires that intensivists should manage care in the Intensive Care Units. The available data suggest that mortality is reduced when intensivists are involved in patient management. Eight studies were cited by Leapfrog in 2000 to justify the IPS expectations. Three studies used prospective design but none of them found reduction in unadjusted mortality. One of the problems with the eight Leapfrog selected reference studies is that the types of ICUs analyzed varied widely. Some of the ICUs were open (intensivist is available if necessary as a consultant to primary care physicians who are managing their patients) while others were closed (the staff intensivist is solely responsible for the management of the patient until the patient is in the ICU) type.

An other problem as Manthous notes is that the type of study intervention is very heterogeneous. Some studies even used the change from open to closed model as intervention. Organizational settings (university medical centers, community hospitals and teaching hospitals) were widely different, too. For the first IPS subcategory, Manthous concludes that although no publication have demonstrated harm associated with intensivist care, the strength of the relation of intensivist staffing and improved mortality in the Leapfrog analysis may have been overstated.

The evidence indicates that the lengths of stays are reduced when intensivists are involved in the care of the critically ill compared to when intensivists are not involved. However, studies found that in many cases similar reduction in lengths of stays can be achieved by implementing and following evidence-based protocols. It is unclear at this point that the observed lengths of stays reductions are the consequence of implementing intensivists' care or that the intensivists are implementing evidence-based protocols and by implementing the protocols without employing intensivists (which certainly would cost less for the hospitals) would achieve the same result for lengths of stays reduction.

The second subset of IPS standards suggests that intensivists should staff ICUs during daytime hours a minimum of eight hours. Manthous concludes that there are insufficient data to demonstrate that ICUs with on-site intensivists working a minimum of eight hours per day have better outcomes than other ICUs. None of the eight studies cited by Leapfrog addressed this requirement in any way. Leapfrog used a post hoc telephone poll of study authors to ask about the number of hours intensivists spent in the ICUs and found that intensivists spent eight hours seven days a week on site. However, there is no study in the literature that would investigate if fewer hours per day and days per week on-site coverage would result in worse outcome.

The third subset of IPS standards claims that intensivists should respond to more than 95 percent of the calls for assistance within five minutes. Similarly to the on-site requirement subcategory, there is no literature evidence for this recommendation. Leapfrog ran the post hoc survey to find out how long it took for intensivists to respond (according to the best knowledge of the study authors) and found that in every study pages were returned within five minutes 95 percent of the time. However, no study was specifically designed to test this requirement, so there is no evidence how this requirement contributed to the improvement of mortality.

The last subset of Leapfrog's IPS recommendations expects that intensivists or extenders should arrive at the bedside within five minutes in 95 percent of cases. Manthous found that there are no data to substantiate this standard nor are there any data to demonstrate that the Society of Critical Care extenders certification course achieves the desired outcomes. Reviewing the study locations reveals that most studies cited were performed in teaching institutions, so most likely residents and not certified intensivist-extenders responded to the bedside and these residents contacted the intensivists when thought it to be appropriate.

One of the basic criticisms of the Leapfrog IPS standards is that even if the standards were fully rooted in evidence, a nation-wide implementation would be impossible because there would be a serious shortage of intensivists (Gropper and Matthay, 2004). The findings of the Committee on Manpower for Pulmonary and Critical Care Societies states that currently intensivists provide care to only 37 percent of all critically ill patients and that by the year 2030 there will be a shortfall of critical care specialist hours by 35 percent. This prognosis did not include a possible national implementation of the IPS recommendations that would exacerbate the manpower shortage by magnitudes. Although the problem with manpower is not related to the evidence base of the standard it seriously questions the practicality and feasibility of its implementation.

Manthous concludes that: "Many of the Leapfrog Group's standards for critical care are not grounded sufficiently in evidence to mandate their stringent and universal implementation… These guidelines make common sense, however, and if sufficient manpower were available, they could serve as the starting point to formulate realistic goals."

Summary of Support and Limitations

Based on the literature of the critique of the IOM study we can safely argue that the initial IOM paper presented an inflated view of the magnitude of medical error caused hospital death rate. On the other hand, there is no doubt in the body of literature that in-hospital deaths occur due to substandard care. However, the true death rate is most likely significantly lower than what was presented in the IOM publication. Because the Leapfrog Group's patient safety initiative cites the same studies as basis of calculations and uses the same death rates as reference values the importance of the Leapfrog initiative as a practical tool for patient safety becomes questionable as well.

In subsequent sections the chapter analyzed the body of evidence in the literature for the specific three Leapfrog safety proposals. Specifically was reviewed how well they adhere to the self-stated Leapfrog criteria of safety standards, that is that the standard should have strong evidence base in the literature and ready for implementation. Systematic review articles and manually selected most recent publications in the relevant topics were used to get a clearer picture of the literature on Leapfrog's recommendations.

The body of evidence in the literature for Computer Physician Order Entry is very limited if those articles are considered only that have a strong scientific basis. There is no statistically significant finding that CPOE implementations reduce the occurrence of preventable adverse drug events (the only medication error category that has practical significance from a patient safety point of view). Similarly, there is no literature support for the claim that CPOE systems reduce total cost or resource utilization per admission.

Health Care Innovation Adoption

The question naturally is that what course of action would hospital management decide on based on the ambiguity of the evidence and implementation readiness of the Leapfrog Initiatives. Basically, none of the three Leapfrog measures is supported unanimously when only scientifically valid studies are considered in the literature. Also, hospital management should contemplate a specific measure's implementation readiness. What would hospital management most likely to decide on? Why would they decide to implement any of the measures at all? Would they adopt all measures or just some of them? To answer the above questions and understand why the paper focuses on the CPOE adoption of the three Leapfrog Initiatives we should study if the emergence and adoption of the Leapfrog measures is a unique phenomenon in the history of health care management innovations or that it is part of a pattern.

First of all, it should be clarified if the Leapfrog Initiatives could be called innovation. A variety of operational definitions of innovation exist. One definition is whether the innovation was created within the organization (Aiken and Hage, 1971). Another way to define innovation is to focus on practices that are new to the organization adopting them. "The idea can be either new or old in comparison to other organizations so long as the idea has not been previously used by the adopting organization" (Daft, 1982). This paper defines the adoption decision of the various Leapfrog initiatives by hospital management as a decision on a management innovation based on the latter definition.

Because the Leapfrog initiatives are in some essence a collection of various recommendations that emerged over time, Leapfrog could be regarded as a "vehicle of communication" for the particular initiatives. This is true even if the initiatives enjoy an ambiguous level of support in the literature as we saw before. Consequently, when Leapfrog came along some of the hospitals already adopted the initiative. They submitted to the various pressures that culminated in the emergence of Leapfrog.

Researchers found that for decades the hospital environment has been described as turbulent and hostile and at the same time, the transfer of business practices into hospitals has been advocated, accompanied by the mostly untested assumption that these practices are crucial to performance and even survival (Bigelow and Arndt, 2000). Others published similar findings (Walston, 1999 and Walston and Kimberly, 2001). These authors found that a "pattern of management innovations" (Bigelow and Arndt, 2000) or a "cycle of managerial adoptions" (Walston, 1999) can be observed in the health care sector. Both terms describe the same issue. A "crisis" is touted in the trade press and with the help of consultants a managerial innovation that is claimed to work in similar circumstances in the business sector is propagated throughout the health care industry.

Soon after the widespread implementation of the "miracle cure" of the "crisis of the time" the innovation fades and a new innovation is elevated to the level of management panacea. The claimed target of the "crisis" changed over time from purely cost to quality or a mix of cost and quality but the pattern is very similar. As the authors note: "The specific practices advocated for hospitals have differed over the years - from cost accounting to corporate restructuring to reengineering - but the claims are similar. Hospitals that adopt the practice will reap significant strategic or operational benefits: costs will go down, efficiencies will be achieved, and market share will improve. Hospitals that do not adopt will fail to thrive, or at worst, will not survive.

A consistent pattern of behavior has emerged. The same strategy (adopting practices from business) is used repeatedly to achieve a desired end (lower costs, survival). Repeatedly it fails to achieve that end; yet it is used again and again, each time with the claim that this time will be different. This time it really addresses fundamental issues, this time hospitals will achieve sustainable savings and efficiencies and will become more competitive." (Bigelow and Arndt, 2000).

The most known management innovations that were transferred from the business sector to the health care arena are matrix management, reengineering and total quality management (Walston, 1999, Westphal et al., 1997 and Burns, 1989). Matrix management encompasses an entire series of efforts to lay one or more new forms of departmentalization on top of an existing form. This hierarchical overlay is a defining characteristic of matrix programs (Burns, 1989). These programs were particularly favored in the 1960s and 1970s. Later, in the 1980s and 1990s came total quality management and reengineering as solutions for quality, cost and efficiency problems of the health care industry. As one article noted, "by the end of the 1980s the assumption that business practices were necessary and appropriate continued to be well entrenched, culminating in the incorporation of TQM into the accreditation requirements of the Joint Commission on the Accreditation of Healthcare Organizations" (Bigelow and Arndt, 2000).

This example is striking because the Leapfrog Initiatives were endorsed without any further evaluation of the evidence to be included in the 30 safety practices suggested by the National Quality Forum (The Leapfrog Group, 2005). The National Quality Forum's Board includes representatives from two federal agencies, the Center For Medicaid and Medicare Services and the Agency for Health Care Research and Quality. Based on that fact it is possible that what happened to TQM will happen to the Leapfrog Initiatives and at least some of them become part of the official requirements of hospital accreditation.

As Bigelow and Arndt writes: "For many decades the basic scenario has been the same. First, the environment is declared hostile, turbulent, and unprecedented with respect to the pressures that threaten hospitals' very survival. Next, hospitals are encouraged to be more businesslike and to adopt specific practices from the for-profit sector. The specific practices have changed over the years, but all promise some combination of greater efficiency, improved competitiveness, lower costs and growth. Anecdotal evidence and normative appeals are used to convince hospital management of the vital necessity of adopting each practice. The practice disseminates widely, although substantive data documenting that the practice realizes its promise are lacking. … Yet inevitably the underlying problem it is promised to address will persist. In time the practice is supplanted by yet another one, holding out similar hope. Two interrelated forces help to explain the embeddedness of this pattern: the assumption that business does it better and a lack of disconfirming evidence."

The assumption that business does it better comes up repeatedly in the various Institute of Medicine reports on health care quality, too. For example, the report titled "To Err Is Human" refers to other industries as examples to be followed for various safety practices and principles (Institute of Medicine, 1999). There is also an obvious "push" in the recent literature for emphasizing quality. One clear example of this process is the distribution of quality related reports published by the Institute of Medicine over the years. 99 of the 361 reports were classified as quality related on the IOM website, that is about 27 percent of all the reports published since 1970. 68 percent of these quality reports were published in the last four years, between 2001 and 2004. In 2002 and 2003 almost half of the published reports (42 and 46 percent respectively) were classified as quality related. Based on these facts and the literature on health care management innovation adoption cited above, one might argue that the quality and safety practices became the latest "crisis of the time" of the health care industry for what the solution is expected to come from the business community.

How do hospitals adopt management innovations? Are technical merits and efficiency the only motivating forces or are there other reasons of adoption as well? Do early and late adopters differ in their motivation? Do hospitals adopt only those management innovations that are proven to be effective? If we know the answers to these questions we can safely argue what can be expected from hospitals regarding the adoption of the Leapfrog measures.

Researchers of organizational networks found that technical factors could be more important in case of organizations adopting innovations earlier in a given network while nontechnical factors may be more important among later adopters (Tolbert and Zucker, 1983). Although the above finding was presented outside of the health care sector, similar study results were published in health care, too.

Mimetic forces have been found to play a major role in the spread of innovations across hospitals (Luft et al., 1986). Others found that the professional media advanced the mimetic forces in the spread of unit management as a form of matrix management in hospitals by publishing a flurry of articles in health administration journals without presenting much supporting evidence (Burns and Wholey, 1993). They also found that normative forces may also have been present. Various local and regional networks were formed of professional organizations, planning councils and federal agencies.

Burns and Wholey reported that in case of matrix management programs hospitals adopted the new structures because of mimetic forces and normative pressures (Burns and Wholey, 1993). They conclude that the findings have an important implication for future implementations of continuous quality improvement (CQI) methods in hospitals because "the matrix adoption models suggest organizations may implement these approaches primarily for nontechnical reasons, including desires to gain prestige, to emulate larger rivals that have already adopted CQI, and to foster the appearance of quality. Like matrix management in hospitals, the adoption of CQI may reflect conformity to institutionalized norms regarding state-of-the-art management methods" (Burns and Wholey, 1993).

Among all of the adoption of management innovations in hospitals, researchers studied reengineering probably the most extensively. However, over time reengineering became a mean-all phrase. Basically, almost all changes in hospitals became explained by management as consequences of "reengineering" (Walston, 1997 and Walston, 1999). In case of reengineering this was possible because until Walston's studies there was not a clear set of requirements that change efforts should fulfill to make the process eligible for calling it reengineering. Others reported similar findings for both reengineering and total quality management (Arndt, 1995 and Arndt and Bigelow, 1998).

For the various Leapfrog measures the situation is different. Leapfrog set up a clear set of requirements for all three measures and at least self-reporting is required for each organization. In case of CPOE implementations have hospitals the only wiggle room by declaring a later date for full CPOE compliance. They do not have the same possibility for EHR volume standards or ICU physician staffing measures. This characteristic is one of the features that make CPOE standing separate from the other two Leapfrog measures and more in line with the other management innovations: total quality management, reengineering and matrix management.

Similarly to the matrix management studies, findings show that hospitals adopt the total quality management and reengineering processes for technical as well as nontechnical reasons. Most of the findings suggest that early adopters are pursuing more of the technical, efficiency gains of the adoption while later adopters are more interested in nontechnical, that is legitimacy benefits (Walston and Kimberly, 2001 and Westphal, Gulati and Shortell, 1997). One study found that contrary to the differing adoption benefits pursued by the various organizations, the timing of the adoption was not explained by organizational factors. That is hospitals that restructured as early adopters did not differ from late adopters as far as the studied organizational variables (bed size and inpatient utilization) concerned (Arndt, 1995). This finding is somewhat contradicting to the general literature where early and late adopters are found differing in pursued benefits (Walston and Kimberly, 2001 and Westphal, Gulati and Shortell, 1997).

Hospitals that already adopted Leapfrog's CPOE measures are early adopters by definition. The percentage of hospitals having an operational CPOE system was less than ten percent at the time of the study period (end of 2002 beginning of 2003) by most studies. Even the highest number was assumed to be 20 percent only (Foster and Antonelli, 2002 and Healthcare Information and Management System Society, 2002). Some researchers define early adopter institutions as the first 20 percent of facilities to adopt an innovation while others declare the first 30 percent to be early adopters (Rogers, 1983 and Walston and Kimberly, 2001). Based on Walston's and Kimberly's definition of early adopters (first 30 percent) and the literature on CPOE implementation surveys this paper assumes that all the study hospitals that already implemented CPOE or are currently implementing it are early adopters. Hospitals that are in the planning phase and declared a later date for adoption are assumed to be late adopters.

Both the reengineering and total quality management studies developed theoretical models mostly based on institutional theory to explain the differences between early and late adopters (Walston and Kimberly, 2001 and and Westphal, Gulati and Shortell, 1997). Sometimes they used a mix of economic and institutional theory (Zinn, Weech and Brannon, 1998). Institutional theory was used to explain adoption behavior of late adopters. The institutional theory was utilized to show the role of legitimacy. Legitimacy and reputation was not used as resource for the organization but as a goal the organization is trying to achieve. On the other hand, the literature indicates that reputation and legitimacy are important intangible resources (Heischmidt et al., 1991 and Romanelli, 1991).

This paper will rely on an economic model developed by utilizing the resource dependence theory and will consider legitimacy and reputation as important resources for hospitals. However, the reengineering and total quality management adoption studies cited above explain well that even if hospital management would find that a particular management innovation has no technical or efficiency merits it might still be inclined to adopt it (Walston and Kimberly, 2001 and and Westphal, Gulati and Shortell, 1997). That is although the management concludes that the hospital would not gain any efficiency benefit by adopting the particular management innovation they jump on the bandwagon and adopt it anyway to gain legitimacy in the eye of stakeholders. Some researchers even go that far that they suggest to health care managers to symbolically adopt the management innovation while pouring resources into the solution of more "important tasks".

As these authors note "Most hospital executives must decide whether to adopt a new practice such as reengineering before they know what impact it has on performance. If they wait until other hospitals have adopted the practice and for its impact to be documented, a possible competitive advantage may have been lost. If they adopt before the impact is known and the practice does not yield the anticipated benefits, executives may have disrupted the organization and committed significant resources to no avail." they also note that other than technical, efficiency benefits "there may be other reasons for adopting. Specifically, laying claim to the practice may associate the organization with widely held beliefs or valued activities and signal to important stake-holders that the hospital is well managed. That in itself may be a sufficient reason for adopting if it enhances the hospital's legitimacy and access to resources, such as managed care contracts, physicians and other clinicians, or patients." (Arndt and Bigelow, 1998).

In a separate study the same authors found that hospitals use their annual reports to educate their important constituencies about various management innovations that were adopted (Arndt and Bigelow, 1999). The findings also suggested that the first hospitals to adopt a management innovation sought to educate stake-holders about the innovation by devoting a greater share of their annual report to the topic than later adopters. Early adopters also enumerated a larger number of anticipated benefits, which would have enhanced the innovation's legitimacy in the early years. This finding supports the assumption that hospitals look legitimacy as a very important resource for the organization and a theory focusing on organizational resources provides an appropriate model for framing the study.

Summary

What of the three Leapfrog safety suggestions would most likely fit the pattern of management innovation adoptions? Overwhelming evidence in the literature supports none of the three measures. The ambiguity over the evidence contributes to an expectedly varied response from organizations as managers will make decisions based on their different life experience and "gut-feeling" (Walshe and Rundall, 2001). The lack of support for purely technical or efficiency benefits of the adoption of the Leapfrog initiatives would not justify implementing any of them. However, as the body of knowledge on management innovation adoption suggests nontechnical factors are playing important roles in hospital managers' decisions what innovation to adopt.

Based on the literature on innovation adoption one can argue that hospitals will adopt any or all of the three measures if this helps them to achieve their goal of increased access to tangible or intangible resources irrespective of its technical merits. This is particularly true if management's perception is that they should jump on the "bandwagon" of innovation adoption. Walshe and Rundall see this as a problem and as a sign of lack of evidence-based management while it could be that managers do not have the luxury to wait with adoptions until all the evidence is in, as Arndt and Bigelow suggest. However, the literature on the Leapfrog initiatives explains that the ICU Physician Staffing measure lacks feasibility because of the shortage of qualified ICU physician specialists and management unless already has in house expertise would have serious problems of finding critical care physicians. The EHR volume standards and CPOE implementation measures have no such problem.

On the other hand, the EHR volume standards are falling somewhat outside of the control of individual hospitals. Hospitals have limited control over how many specific procedures are done among their walls because the referral patterns are usually established and the number of surgical procedures done in a geographic area is well-established and hard to change. The above feasibility and control limitations leave CPOE implementation as the only real choice of management innovation that is most within the control of a particular organization and has a high feasibility for implementation. This is also the only Leapfrog measure that has a "built-in" wiggle room for late adopters by allowing declaration of full compliance at a later date. Consequently this paper focuses on the CPOE adoption of hospitals as the most likely candidate of the three Leapfrog initiatives to fit the literature described pattern of management innovation adoptions.

Reputation and legitimacy are important intangible resources and gaining access to them is valuable benefit. The literature explains the role of legitimacy using mainly institutional theory and focusing mostly on late adopters. This paper argues that using an economic, resource dependence theory organizations' management innovation adoption behavior could be explained. Resource dependence theory can be used to frame the study hospitals' different economic, financial, operational and environmental conditions and

constraints for early and late adopters as well for both tangible and intangible resources.

This study will add to the body of knowledge on management innovation adoption by using a single economic theory to describe organizations' behavior in innovation adoption. In addition, the study will add to the present knowledge on information technology adoption of hospitals in general and will broaden the literature on CPOE systems by adding an organizational theory perspective on hospitals' CPOE adoption.

Chapter 3: THEORETICAL FRAMEWORK

The purpose of this chapter is to provide a theoretical framework and conceptual model for the study using resource dependence theory. A recent systematic review of the literature on the diffusion of innovations in service organizations recommends studies on innovation adoption being theory driven. As the authors note, studies should explore an explicit hypothecated link between an intervention or program and a defined outcome (Greenhalgh, Robert, Macfarlane, Bate and Kyriakidou, 2004). On the other hand, the present literature can not provide guidance in predicting organizational, financial and environmental characteristics of CPOE adopting institutions because basically none of the studies in the literature make use of any organizational theory as framework. Very few social science theories are utilized at all. Ash used theory framework by applying diffusion of innovation theory (Ash, 2001) but there is no other theory framework based CPOE publication.

One explanation for the lack of use of organizational theory as framework in CPOE studies is the relative recency of CPOE as a health care industry phenomenon. Especially the early studies were focused on qualitative, descriptive aspects of the implementations. The other possible explanation why organizational framework was not used in CPOE studies is the lack of reliable databases where CPOE adopter hospitals could be identified in a critical mass and cross linked to databases with organizational characteristics. The American Hospital Association annual hospital survey databases were available since 1980 but the first article in peer-reviewed journal that mentioned CPOE as a health care information technology tool was published only in 1986 (Schroeder and Pierpaoli, 1986). In the next ten years sixteen peer-reviewed articles were published about CPOE all of them descriptive case studies.

No quantitative database or a list of hospitals that implemented CPOE was available either so studies based on organizational theory framework or any social science theory framework that needed sufficiently large database to produce statistical significance were not feasible. The number of peer-reviewed CPOE publications reached fifty in the previous two-year period (2001 and 2002) and 56 in 2003 and 42 in 2004. Although more than half of all the CPOE peer-reviewed articles were published in the last four years, a database that provided comparative organizational data became available only with the foundation of the Leapfrog Group. The Leapfrog Group began collecting data in 2001 (Leapfrog Group, 2004).

At present time the Leapfrog Group is the only known source of reliable survey data regarding CPOE implementations in hospitals that create the possibility to use comparative organizational theories for research framework. It is also conceivable that the organizational perspective has been undeveloped because the organization has not been seen as the strategic actor in CPOE adoptions but it was looked as a medical staff decision instead. Although understanding the human side of CPOE adoptions is very important and further research is needed in both this area and also to get a definitive answer if CPOE reduces patient mortality or total cost per admission, we should not forget that not individuals but organizations are adopting CPOE. Success or failure to implement CPOE or the willingness to adopt CPOE is in the reach of organizations and not a single manager of the organization. Decisions of the organizations' managers and leadership are limited by external environmental and internal organizational, financial and operational factors.

In addition, we can not continue to look the possibility of CPOE (or any Information Technology) implementation as if the new technology would be implemented in a quasi-void space. Especially not in case of such a complex technology as CPOE which itself is a system of simpler technical parts. Any CPOE implementation attempt will require serious behavioral and organizational changes in the "host" institution. When various parts of CPOE are implemented they interact with other parts of the greater system of the organization, hospital in this case. Just as the organization interacts with its environment. As Scott says: "There is no need to belabor the assertion that ours is an organizational society – that organizations are a prominent, if not the dominant, characteristics of modern societies." (Scott, 1992).

It is important to understand what organizations do and how they do it because "the development of organizations is the principal mechanism by which, in a highly differentiated society, it is possible to 'get things done', to achieve goals beyond the reach of the individual" (Parsons, 1960). If we focus exclusively only on the human side of the "whys" and "hows" of CPOE adoptions in as complex systems as hospitals, then we will never grasp the true nature of driving forces in hospital CPOE adoptions. Without studying organizational level characteristics and responses we will not understand how ‘things get done’ in hospitals, that is, how and why CPOE ‘gets implemented’ in some hospitals and not implemented in others.

Level of Analysis

Organizational Theory is a broad term. Organizational studies differ in the level of analysis at which the work is done (Blau, 1957). As Scott states: “the level of analysis is determined by the nature of the dependent variable – that is, by whether the phenomenon to be explained is (1) the behavior or attributes of individual participants within organizations, (2) the functioning or characteristics of some aspect or segment of organizational structure, or (3) the characteristics or actions of the organization viewed as a collective entity.” (Scott, 1992). This study and the study’s theory framework are focused on the level three part of the above definition. The level three analysis is also defined as ecological level of analysis. This study utilizes an ecological analysis of hospitals facing the environmental challenge to adopt or not to adopt CPOE.

The dependent variable of the study is the action of the hospital as collective entity to choose to adopt or not to adopt CPOE when facing environmental pressures. The notion that organizations are not closed isolated entities but they operate in constant exchanges with their environment is generally accepted among organizational researchers. “Every organization exists in a specific physical, technological, cultural, and social environment to which it must adapt. No organization is self-sufficient; all depend for survival on the types of relations they establish with the larger systems of which they are a part.” (Scott, 1992). In case of hospitals, this interdependence with the environment is obvious. One of the five major ecological models to address analysis in the open natural system organizational theory is the resource dependence framework (Scott, 1992). This study is utilizing the resource dependence perspective.

Resource Dependence Theory

The "resource dependence model emphasizes adaptation. It is assumed that individual organizations can act to improve their chances of survival. … This perspective is strongly rooted in an open system framework: it is argued that one can not understand the structure or behavior of an organization without understanding the context within which it operates. No organization is self – sufficient; all must engage in exchanges with the environment as a condition of their survival. The need to acquire resources creates dependencies between organizations and external units. How important and how scarce these resources are determine the nature and the extent of organizational dependency. organizations are viewed as active, not passive, in determining their own fate.

Organizational participants, particularly managers, scan the relevant environment, searching for opportunities and threats, attempting to strike favorable bargains and to avoid costly entanglements. All organizations are dependent on suppliers and consumers but which specific exchange partners are selected and what are the terms of exchange is partly determined by the organization itself." (Scott, 1992). Adaptation to the environment is reflected in changes in organizational structure or behavior (Banaszak-Holl et al., 1996).

In resource dependence theory the resources that have importance for an organization can have different shapes. Resources could be tangible, for example people or revenue. On the other hand, there are intangible forms of resources that could be very valuable for an organization as well. Reputation and legitimacy are such kind of resources that play important roles in the resource dependence model. The central thesis of resource dependency is that in order to understand the behavior of an organization the researcher should understand the context of that behavior, that is the ecology of the organization. Pfeffer and Salancik state that organizations' existence is constantly in question and their survival is viewed as problematic (Pfeffer and Salancik, 2003).

Organizations survive to the extent that they are effective. Their effectiveness derives from the management of demands, particularly the demands of interest groups upon which the organizations depend for resources and support. One way for organizations to manage these demands is to give in to them. The key to organizational survival is to acquire and maintain resources. There are resources that are more important for some organizations than for others. "A good deal of organizational behavior, the actions taken by organizations, can be understood only by knowing something about the organization's environment and the problems it creates for obtaining resources. What happens in an organization is not only a function of the organization, its structure, its leadership, its procedures, or its goals. What happens is also a consequence of the environment and the particular contingencies and constraints deriving from that environment." (Pfeffer and Salancik, 2003). When environments change organizations face the prospect of either not surviving or changing their activities in response to the changing environment.

Pfeffer and Salancik also noted that "… Organizations engage in exchanges and transactions with other groups or organizations. The exchanges may involve monetary or physical resources, information, or social legitimacy. Because organizations are not self-contained or self-sufficient, the environment must be relied upon to provide support. For continuing to provide what the organization needs, the external groups or organizations may demand certain actions from the organization in return. It is the fact of the organization's dependence on the environment that makes the external constraint and control of organizational behavior both possible and almost inevitable.

Organizations could not survive if they were not responsive to the demands from their environments. But, we have noted that demands often conflict and that response to the demands of one group constrains the organization in its future actions, including responding to the demands of others. This suggests that organizations cannot survive by responding completely to every environmental demand. The interesting issue then becomes the extent to which organizations can and should respond to various environmental demands, or the conditions under which one social unit is able to obtain compliance with its demands. By understanding the conditions of the social control of organizations, we believe it is possible to understand how organizations decide to comply with, or attempt to avoid, influence. …We would concur that, in general, organizations will tend to be influenced by those who control the resources they require. But there are a number of other conditions, which increase the likelihood of the influence being successful. Below is a list of the conditions which affect the extent to which an organization will comply with control attempts:

1) The focal organization is aware of the demands.
2) The focal organization obtains some resources from the social actor making the demands.
3) The resource is a critical or important part of the focal organization's operation.
4) The social actor controls the allocation, access, or use of the resource; alternative sources for the resource are not available to the focal organization.
5) The focal organization does not control the allocation, access, or use of other resources critical to the social actor's operation and survival.
6) The actions or outputs of the focal organization are visible and can be assessed by the social actor to judge whether the actions comply with its demands.
7) The focal organization's satisfaction of the social actor's requests are not in conflict with the satisfaction of demands from other components of the environment with which it is interdependent.
8) The focal organization does not control the determination, formulation, or expression of the social actor's demands.
9) The focal organization is capable of developing actions or outcomes that will satisfy the external demands.
10) The organization desires to survive.

It is not necessary that all conditions be present for influence to be observed. We would argue, however, that as more of the conditions are met, the probability of external control becomes more and more likely." (Pfeffer and Salancik, 2003).

Application to the Current Study

To fully understand how hospitals as organizations interact with other organizations and what are the driving forces of the interactions we must first discuss the hospitals' environment and how hospitals are embedded in this environment. It is also important to clarify what might identify as resource for hospitals from the point of view of this paper's analysis.

It is not always easy to define what constitutes the external environment. According to Pfeffer and Salancik there are three levels of definition of the environment. On the first level, "the environment consists of the entire system of interconnected individuals and organizations who are related to one another and to a focal organization through the organization's transactions. The next level is the set of individuals and organizations with whom this organization directly interacts, [and] the third level of the organization's environment can be characterized as the level of the organization's perception and representation of the environment – the enacted environment" (Pfeffer and Salancik, 2003). The third level, the enacted environment is the most important and it is the one that determines the organization's actions.

The first level of environment for hospitals facing the decision to implement or not to implement CPOE is the entire health care system. This level includes all "players" of the nation's health care system. It includes all the other provider organizations, the physicians, the patients, the payers and the various regulatory agencies. The second level of environment is a much smaller "circle" of environmental entities with which the hospital directly interacts during fulfilling its mission. This "circle" includes the patients who receive care in the hospital, the payers the hospital gets reimbursed by for its services, other provider organizations where patients are transferred to and from and regulatory bodies directly responsible for regulating the specific hospital. The third, enacted level of environmental entities includes the Leapfrog Group member employers and payers influenced by the Leapfrog Group members as well as potential patients.

Figure 1 represents the various levels of environment based on Pfeffer and Salancik's environment definition for hospitals in this study. This representation is assumed to be valid only for the resource exchange part of the environment that is related to the CPOE challenge (adopt or not to adopt CPOE) of the particular hospital in the study. We can expect to see different enacted environment "shapes" for different kind of resources changing dynamically based on the nature of the necessary resource and challenge.

This study is concerned with the enacted environment of the hospital for getting the financial resources for its survival facing the CPOE adoption challenge. The right lower rectangle shows the enacted environment of the hospital. As it can be seen the level three, enacted environment overlaps parts of the other two levels and it includes entities that might not be categorized as strictly part of the health care (level one) environment. Particularly entities as the Leapfrog Group (LFG), employers (EMP) and potential

patients (PP) are part of the society in which the health care system is embedded but they are not part of either the level one or the level two environment.

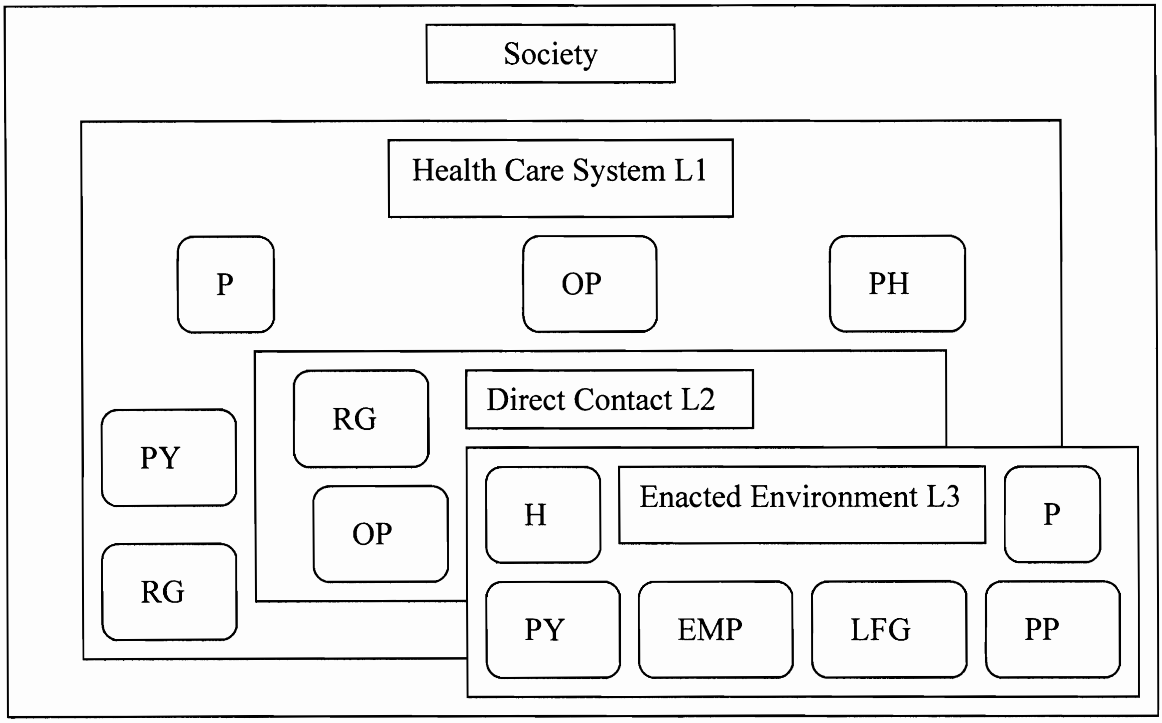

Figure 1. Study Hospital's Relationship With The Levels of Environment

Legend: OP = Other Provider Organization, P = Patients, RG = Regulatory Agency, H = Hospital in Study, PY = Payer Organization, PH = Physicians, PP = Potential Patients, LFG = Leapfrog Group, EMP = Employer

Nonetheless they are part of the enacted environment of the hospital struggling for its survival. This representation also illustrates why the notion of enacted environment is so important. Including the enacted environment in the organizational theory framework creates the possibility to include those external entities that clearly have an effect on the survivability of the hospital but can not be categorized as level one or level two entities.

The Leapfrog Group was created by the Business Roundtable that is a national association of Fortune 500 CEOs. The Business Roundtable (BRT) member companies directly employ more than ten million Americans and indirectly are the source of health insurance coverage for other twenty-four million (Business Roundtable, 2004 and The

Leapfrog Group, 2004). The employees and their corresponding family members of the BRT group companies are located in urbanized areas, consequently BRT companies have direct influence over fifteen percent of the urbanized US population (225 million) (US Census Bureau, 2004). Because this paper studies hospitals that are located in urban areas gaining or losing access to over fifteen percent of the market especially in competitive hospital markets can make or break the survivability of a hospital. Consequently the fifteen percent market "influence" of Business Roundtable (Leapfrog Group) employers undoubtedly registers on the radar of hospital management. Other employers look to these large buyers as role models, consequently the BRT member companies directly and indirectly have influence over more than the fifteen percent of the Metropolitan Statistical Area population.

In addition, it is a well-documented finding that patients receive most of their informal (that is not from direct health care source) health care related information from word of mouth (Biley at al., 2001 and Carlsson, 2000). The studies of health care related information sources for people document mostly cancer patients' information sources or information source of people who are already patients (Budtz and Witt, 2002). Studies of the general population also found that word of mouth is one of the most important source of information in making health care choices (Bates and Gawande, 2000). Studies consistently found that patients seek their informal health care advice from their friends and family members in 40-55 percent of the cases (Biley et al, 2001 and Carlsson, 2000). Beside employers, family members and friends potential patients can find the comparative CPOE information of hospitals' CPOE ratings from various report cards directly from the Leapfrog Group web sites or other report card sites from the internet. It is also documented that report cards have effect for example on managed care enrollment, especially if the information is framed using a risk message (Scanlo et al, 2002 and Hibbard et al, 2000). There is no reason why we should doubt that report cards would work similarly for people's hospital choices.

Consequently, we can argue that there are at least three different ways how consumers, potential patients can gain access to information about their hospital choice. There are two important notions in here. First, people in those urban areas where the Leapfrog Group initiative is rolled out are influenced directly (if they are Business Roundtable member employees) through their employers or indirectly (the wider population in the Leapfrog Group rollout area) through word of mouth in their choice of hospital selection. The direct influence means gained or lost business for the hospital for fifteen percent of the potential market population and the indirect influence means some additional share of the market. In addition, the population might have access to summaries of the comparative information of the market area's hospitals from lay press.

There is no study about the general press' effect regarding the Leapfrog initiative but an earlier study found that press reports of single, unexpected deaths were associated with an average nine percent reduction in hospital discharges within a year (Mennemeyer, et al., 1997). Second, we should consider the effect of the Leapfrog Group initiative on the potential patients not on the actual patients the hospital is in direct contact with. Actual patients are part of the level two environment but the potential patients are part of the level three, enacted environment of the hospital. This second notion has broader implications for the hospital selection of people in the hospital's market area. We will use this aspect of the enacted environment in our study.

Leapfrog Group influenced potential patients might want to prefer health plans (if they have a choice) for their health plan enrollment when the plan has a choice of a favorably rated CPOE implementing hospital. These potential patients might shun those plans (again if they have a choice) that do not contract hospital services with positively rated CPOE implementing hospitals. In effect, health plans become interested to contract hospital services with those hospitals that have a favorable CPOE implementation rating. The plans' interest adds an additional pressure on hospitals (from plans directly) to implement CPOE if they think this helps the survival of the organization. Both assumptions about the people's and HMO's choice in hospital selection are supported by the literature. Study results indicate that people select hospitals at least partly based on the perceived quality of care in the hospital (Luft et al, 1990). Other studies indicate that health care plans prefer to contract with hospitals that have higher perceived quality (Gaskin et al, 2002 and Mukamel et al, 2001).

Based on Scott, Pfeffer and Salancik's descriptions of the resource dependence theory this study argues that hospitals in the various urban markets of the US health care system where the Leapfrog initiative is rolled out are facing an environmental challenge. The environmental challenge was of course present even before Leapfrog rolled out its initiative in the particular area but Leapfrog's action serves as amplifier that intensifies the challenge. The Leapfrog initiative can be also seen as a focusing event that makes an imminent action required by the hospitals.

The nature of the challenge is about the decision to implement or not to implement the CPOE requirements of Leapfrog. From the point of view of this study one of the resources the hospital needs to acquire from the environment is the revenue the hospital receives for provided services. This "resource" is scarce in the environment and competition for that resource can be intense. Even if the hospital is the only hospital in the market this "resource" is at least finite. In case of other hospitals providing services in the same market the "resource", the revenue source becomes scarcer as it is the focus of competitive behavior.

This study argues that CPOE adoption and subsequent implementation is the adaptation step study hospitals are taking to comply with the environmental change. The Leapfrog Group CPOE initiative rollout in a specific area is the particular environmental change the study hospitals should adapt to. In the Leapfrog rollout areas hospitals should adapt to the environment by making a risky decision about the CPOE implementation. This is not an easy decision for the hospital. There is considerable risk in both ways of the decision. According to the Leapfrog experts a fully Leapfrog compliant CPOE system could cost between 500,000 and 15,000,000 dollars depending on the bed-size of the hospital and the level of preparedness to implement the standards (The Leapfrog Group, 2004). That is for example if the hospital has any kind of information technology system in place already or not.

If the managers of the hospital who scan the environment for opportunities and threats make a decision to adopt and then implement the CPOE system then they should spend a few million dollars on this step of environmental adaptation. If the CPOE implementation step turns out to be unnecessary for the hospital's survival then the hospital spent important internal resources on an unnecessary adaptation process instead of spending the same resources on a more useful adaptation process for an other environmental challenge. The misspending can bring the hospital closer to the very failure the management wanted to avoid. On the other hand, if a non-implementation decision is made for CPOE and later the hospital will lose significant business because of that decision then the hospital as organization might fail and go bankrupt.

The challenge from the environment is very real and practical. As we described earlier the businesses that created the Leapfrog Group has direct influence over fifteen percent of the people living in the urbanized US health care market and indirect influence over significantly more because of word-of-mouth and report cards. On the other hand, based on the resource dependence theory we can be sure that hospitals are not helpless but they will attempt to be masters of their fate. The hospitals can decide that they implement CPOE if the various environmental circumstances are justifying it as well the internal organizational structures and financial means make this possible and adapt to the challenge. Or the hospitals can decide that the challenge does not measure up to be sizable enough to justify the implementation costs in view of external environment and internal organizational structure, financial means and competing demands and then they decide not to implement CPOE. For example, if the hospital would consider the competition in the specific hospital market weak and its own status in the market strong it might decide that it can preserve its strong position and patient revenue without investing into the Leapfrog Group's CPOE compliance.

Conceptual Model and Functional Form

Figure 2 represents the conceptual model and provides a graphical presentation of the association of environmental, operational and organizational factors as they relate to hospital's adoption of Computerized Physician Order Entry initiative of the Leapfrog Group. It also helps to visualize the focus of the study, as it will be further developed in the "Hypotheses" section.

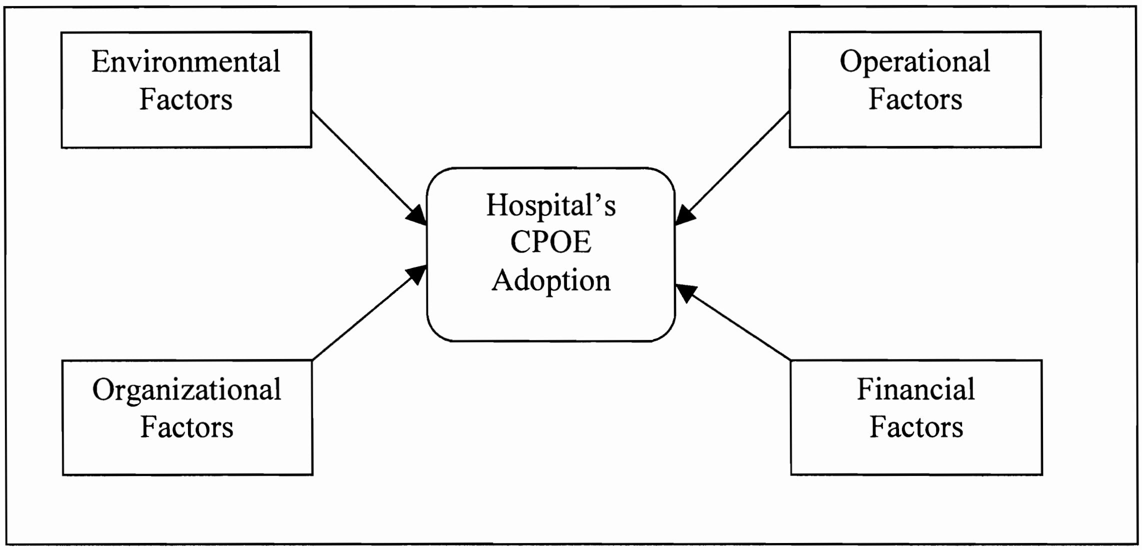

Figure 2. Conceptual Model: The Relationship of Various Factors

The functional form is presented as follows: Hospital's CPOE Adoption Decision = *f*(Environmental, Operational, Organizational, Financial Factors).

The hospital's decision to adopt or not to adopt the Leapfrog Group's CPOE initiative depends on external, the environmental and internal, the operational and organizational factors. The environmental factors tested in subsequent hypotheses are hospital market competitiveness and HMO penetration. Operational factors tested are hospital capacity slack, bed size and physician staffing structure. Organizational factors tested are hospital ownership, community orientation and system affiliation.

Hypotheses

According to the resource dependence theory the stronger the environmental challenge on the organization the more likely the organization will try to adapt to the environmental changes. If HMO penetration is greater in an area and HMOs are encouraging CPOE implementation then higher HMO penetration will lead to stronger environmental effect on area hospitals. As it was mentioned earlier, in each regional rollout local health plans are contacted by Leapfrog and asked to contact hospitals to encourage them to comply. Health plans are also advised by the regional employer members of Leapfrog to purchase services only from hospitals that comply with the Leapfrog standards. It is known that higher HMO penetration increased the quality of hospital care in area hospitals (Sari, 2002) as well as technical efficiency (Brown, 2003). It is expected that HMOs presence in a specific market will facilitate CPOE implementation in area hospitals.

The HMOs' facilitating influence has two sources. The first source of influence was discussed earlier and it could constitute direct communication from HMOs to market area hospitals explicitly urging the hospitals to comply with the Leapfrog CPOE initiative. HMOs can request the compliance as an indicator of the hospital's quality consciousness. Although no publication supports this assumption to date but the Leapfrog Group provides various toolkits that employers can pass on to contracting HMOs and ask HMOs to explicitly contact hospitals in their area (The Leapfrog Group, 2004). Because no studies found that CPOE implementations are harming either quality or technical efficiency there is no reason why we should doubt that HMOs will try to encourage area hospitals to implement CPOE (Teich et al, 2000, Taylor et al, 2002 and Kuperman and Gibson, 2003).

The second source of influence is related to the perception what hospitals will have about the HMOs. If the general perception in US hospitals is that HMOs will prefer to contract hospitals that implement quality then hospitals with HMO presence in their area will be more likely to implement CPOE without even waiting for the direct influence of HMOs. This perception could be enforced by the fact that several health insurance companies as well as health plans are members of the Leapfrog Group. If the same hospital will receive the "direct" and "indirect" encouragement for CPOE implementation from multiple sources, that is from more than one HMO in the area then it will more likely to adopt CPOE. It is also likely that hospitals located in areas where HMO market share is higher will more likely be inclined to adopt the Leapfrog initiative because the HMOs' point of view will be more likely be considered by hospital management. Hospitals have various numbers of contracts with area HMOs. It is likely that as the number of HMO contracts a hospital have is increasing the level or intensity of the HMO input is increasing as well.

H1a: Hospitals in areas with greater HMO penetration will be more likely to adopt CPOE.

H1b: Hospitals with more HMO contracts are more likely to adopt CPOE.

Dependency theory argues that the level of scarcity of a particular resource in the environment defines the level of dependency of the organization on that particular resource. The more scarce a resource the higher the dependency. Thus we can assume that the more scarce patient population is in the study hospital's market the higher the dependency of the market area hospitals. In competitive environments, organizations share a limited resource pool and survival depends more on how resources are allocated across competitors (Pfeffer and Salancik, 2003). The higher the competition in an area among hospitals the more scarce the patient population is for a particular study hospital. Consequently, the higher the competition of the market area hospitals the higher their dependency on the environment. The higher dependency on the environment will result in more likely adaptation to the environmental challenge, that is adoption of CPOE.

H2: Hospitals located in more competitive markets will be more likely to adopt CPOE.

Resource dependence theory argues that the more important a specific resource is for an organization the higher the organization's dependency on the environment. It is likely that hospitals operating with full or close to full capacity are less concerned of losing some of their patient population and corresponding patient revenue. On the other hand, for hospitals that have excess unused capacity just maintaining the current level of patient volume is very important. No doubt that also this second category of hospitals (with excess capacity) is more interested in increasing the patient volume than hospitals already at full capacity. Patient volume is more valuable for hospitals with excess capacity. Consequently, hospitals with excess capacity are more dependent on the environment and are more likely to try to adapt any environmental change to maintain or increase the level of patient volume.

H3: Hospitals with excess capacity are more likely to adopt CPOE.

According to the resource dependence theory, beside tangible resources organizations need intangible resources as well. Reputation and social legitimacy are both intangible resources. It is hard to argue that if a hospital has no good reputation then eventually it will run into financial problems. Findings suggest that when patients choose a hospital then beside the physical plot, previous experiences with the hospital, location of the hospital and overall cost, the reputation of the hospital is an important factor they consider (Heischmidt, et al., 1991 and 1993). Beside reputation, social legitimacy is also a concern for hospitals.

The resource dependence theory states that some organizations are more dependent on the environment for some resources than others in the same environment. It is easy to argue that social legitimacy is one of these resources. Some hospitals, notably not-for-profit entities are assumed to work more for the public good than for profit institutions. For profit organizations are assumed to be profit maximizers even when their focus of business is health care. On the other hand, not-for-profit organizations are assumed to have a focus on the public good. Obviously, this does not mean that the general public does not expect high quality from all players in the health care system. However, legitimacy and high quality are different issues the hospital should manage in its enacted (third level) environment. In case of not-for-profit hospitals, social legitimacy is a more prominent concern of the enacted environment than it is for investor owned hospitals. Not-for-profit hospitals get tax breaks from almost all taxes and in return the society expects that the hospitals will act in the interest of the public. This expectation is more prominent for not-for-profits than for investor owned hospitals.

There is evidence in the literature that not-for-profit health care institutions behave differently than for-profits do. For example, significant differences were found in financial decision making between not-for-profit and for-profit hospitals. Managers of for-profit hospitals based their financial decisions more on the need to achieve profitability than managers did in not-for-profit hospitals (Walker and Humpreys, 1993). Investing into CPOE is reducing the profitability at least on the short term and because it is a risky decision for-profit organizations will try to at least delay the actual implementation. For-profits will try to show some level of commitment by starting a planning process but will less likely to actually implement it. Consequently, this study argues that not-for-profit hospitals are more likely than their investor owned counterparts to be actual implementers of a new technical innovation if the perception based on the enacted environment indicates that the public expects it.

H4: Hospital ownership will have a significant effect on actual CPOE implementation rate and not-for-profit hospitals will more likely to be actual implementers of CPOE than investor owned hospitals.

According to the resource dependence theory, those organizations that are more dependent on the environment will build a stronger "connection" to that environment. One way for hospitals to build up a stronger "connection" to the environment is to develop a stronger community orientation. Hospitals that will have a stronger community orientation will be more likely to implement a new quality innovation or start a new service if the local community shows signs to expect it (Ginn and Moseley, 2004). Although there is a significant overlap between community orientation and not-for-profit status, community orientation was also found to be significantly higher in hospitals that operate in areas with higher diffusion of community orientation activities (Proenca, Rosko and Zinn, 2000). This finding signals that even for-profit hospitals could be more community oriented if the local market conditions "enforce" it. This study argues that hospitals with higher community orientation are more likely to adopt a quality initiative than hospitals with lower community orientation.

H5: Hospitals with higher community orientation are more likely to adopt CPOE than hospitals with weaker community orientation.

The CPOE literature consistently emphasizes that successful implementation of CPOE requires serious internal organizational and staff behavioral changes (Morrisey, 2003). The resource dependence theory states that internal organizational constraints have a significant effect on what actions are feasible for an organization when manages external environmental pressure. Some hospitals will find it easier to adopt CPOE, or take it less time between planning and actual implementation because of a more favorable internal organizational, operational structure. That is some hospitals have an operating structure that is more "CPOE-ready" than others have. Basically, in all cases of failed CPOE implementation reports of the literature the physician's resistance had a dominant role in the failure (Morrisey, 2003). A survey of senior managers of 25 hospitals found that the presence of house staff and hospitalists is a significant factor in overcoming barriers of the CPOE implementation (Poon, et al., 2003). Clearly, hospitals with an in-house, salaried physician staff structure have less internal constraints when trying to manage the Leapfrog's CPOE environmental challenge than hospitals without employed house staff and/or hospitalists. Consequently, hospitals with a house staff on salary are more likely to find that "giving in to" the environmental challenge is a feasible way of managing the challenge.

H6: Hospitals with in-house salaried physician staff are more likely to adopt CPOE than hospitals without a salaried physician staff.

The CPOE literature indicates that, at least for now, there is no off-the-shelf CPOE system what hospitals can install without significant customization. Survey results show that physicians and senior management found the CPOE system to work best when it was tailored to fit local and individual workflow (Ash, et al., 1999). Even without the intent of perfect fit, CPOE systems need significant customization just to get it off the ground. In order to implement CPOE that is a complex information technology initiative, hospitals need to tweak the system. To do that, hospitals must have access to information technology expertise. The expertise could be internal or external. External expertise can come from the vendor or consultants. Internal expertise would come form in-house information technology staff. Relying on external expertise for implementing, customizing and running the CPOE system introduces additional risk into an already challenging situation. According to the resource dependence model, hospitals (if decide to do so) will implement CPOE because there was an uncertainty, challenge in the environment. The hospital's survival had to be problematic on the first place to even consider implementing CPOE. No management wants to add further hazardous element to the already risky situation by relying on a non-fully controlled external expertise, unless it seems to be the last measure of survival. Because the Leapfrog initiative started only a couple years ago and its effect is not completely certain yet, hospitals that have no access to reliable internal expertise might not feel that they should act right away. They might start a planning process but will try to delay actual implementation and keep watching the environment.

On the other hand, hospitals that have access to internal expertise might "feel" that the balance is tipped for them and feel secure enough, having an IT staff on their own, and conclude that implementing CPOE brings them more security in the environment then potential problems. Hospitals with in-house expertise might be more certain that they could deal with any customization and maintenance problem what a CPOE implementation might cause than hospitals without in-house expertise. However, developing in-house technology expertise is costly. Only hospitals with a larger bed-size capacity to fill could generate enough revenue to develop and maintain in-house technology expertise. There is evidence in the literature that larger bed-size is positively associated with hospital information technology adoption (Glandon and Counte, 1995 and Burke, et al., 2002). Based on the literature and the resource dependence theory, this study predicts that larger bed size hospitals are more likely to adopt patient safety medical technologies.

H7: Hospitals with larger bed-size are more likely to adopt CPOE than hospitals with smaller bed size.

Other way for smaller hospitals to get access to a quasi in-house expertise is to finance technology staff together. It is unlikely that hospitals in the early adoption stages of CPOE where the market is at now will develop partnership for the sole purpose of CPOE implementations, especially unlikely is that for local hospitals that are competitors. However, hospitals that are already working together could develop this partnership more easily and it is very likely that these hospitals already have a technology staff that is financed and managed centrally. In addition, hospitals that are members of an integrated delivery network or hospital chain will more likely have a technology network that connects the hospitals for management purposes. The literature supports these assumptions. Hospitals with delivery networks are implementing electronic integration systems (Morrisey, 1996). There is also support in the literature that hospitals that have system membership are more likely to adopt medical information technology (Burke, et al., 2002). Based on the literature and the resource dependence model, the study argues that hospitals that participate in integrated delivery networks or hospital networks will more likely be able to adopt a new patient safety information technology tool.

H8: Integrated delivery network or system member hospitals will more likely to adopt CPOE than non-member hospitals.

This study argues that Information Technology has its best value when the complexity of services a hospital offers is at the highest level. When the mix of offered services is simple or just a few health care procedures are offered then the need for Information Technology to manage, organize or supervise the orderly delivery of these services is lower than if there are more services offered or these services represent higher complexity. The literature supports this assumption. Complexity of services was found to be a factor for management innovation adoption in hospitals. Hospitals with a higher case mix index were more likely to adopt clinical and administrative information systems (Wang et al., 2005). This study argues that hospitals with more services or more complex services offered are more likely to become CPOE adopters.

H9a: The more services a hospital offers, the more likely it will adopt the Leapfrog Group's CPOE initiative.

H9b: The higher the case mix index of the hospital the more likely it will adopt the Leapfrog Group's CPOE initiative.

Adopting an organization wide CPOE system what the Leapfrog Group requires for initiative compliance is a serious undertaking financially for the hospital. It is easy to argue that hospitals with a higher profit margin can "take on" costly new projects more readily than hospitals with lower profit margin. The literature supports the profit assumption for innovation adoption in general and for Information Technology adoption in particular (McCue, 2000, Zinn, Weech and Brannon, 1998, and Wang et al, 2005). Based on the argument and literature mentioned above this study hypothesizes that higher profit margin makes a hospital more likely to adopt the CPOE initiative.

H10: The higher the profit margin of a hospital the more likely it will be an adopter of the Leapfrog Group's CPOE initiative.

Summary

Resource dependence theory emphasizes individual organizations' adaptation to changing environmental demands. The theory also focuses on the importance of internal constraints originating from operational and organizational characteristics of the particular organization. As it was demonstrated in the description of the theory in this chapter and previous work detailed in the literature review chapter, resource dependence theory is well suited to address management innovation adoption problems in the health care sector on its own without using complementary theories.

Based on the resource dependence theoretical framework a conceptual model of hospitals' CPOE adoption decision was presented. Table 1 summarizes the hypotheses that were developed applicable to the model. The table also shows the result as a positive or negative sign expected for each hypothesis. Hypothesis H1a has a positive expected sign and test HMO penetration rate. Hypothesis H1b has an expected positive sign and tests the number of HMO contracts the hospital have. Hypothesis H2 has an expected positive sign and tests the increased market competition. Hypothesis H3 has an expected positive sign and tests excess capacity. Hypothesis H4 has an expected positive sign and tests not for profit ownership. Hypothesis H5 has an expected positive sign and tests higher community orientation. Hypothesis H6 has an expected positive sign and tests salaried physician staff. Hypothesis H7 has an expected positive sign and tests larger bed size. Hypothesis H8 has an expected positive sign and tests system or network affiliation. Hypothesis H9a has an expected positive sign and tests the number of

Table 1. Expected Results of Hypothesis Testing.

Hypothesis	Factors Tested	Sign
H1a	Higher HMO Penetration	+
H1b	Higher Number of HMO Contract	+
H2	Increased Market Competition	+
H3	Excess Capacity	+
H4	NFP Ownership	+
H5	Higher Community Orientation	+
H6	Salaried Physician Staff	+
H7	Larger Bed Size	+
H8	System/Network Affiliation	+
H9a	Number of Services Offered	+
H9b	Complexity of Services	+
H10	Profit Margin	+

services offered. Hypothesis H9b has an expected positive sign and tests the complexity of services. Hypothesis H10 has an expected positive sign and tests the profit margin.

Chapter 4: METHODS

This chapter describes the study design, provides details of the data and data sources. The chapter also shows the measurement of the dependent and independent variables and further clarifies the scope of the study developed in the literature and theory chapters. The statistical methods used are also discussed.

The study examines the relationship between hospitals' Computerized Physician Order Entry system adoption and internal and external factors. The individual hospital is the unit of analysis. The study population consists of nonfederal acute care hospitals located in the Metropolitan Statistical Areas of the first two waves of Leapfrog rollout regions. The first wave of rollout occurred in 2001 and the second in 2002. Hospitals owned by the federal government such as the Veterans Administration and the Department of Defense were omitted. Specialty hospitals such as psychiatric hospitals were also excluded.

Research Design

Research design can be experimental when the researcher actively intervenes or observational when the role of the researcher is passive. This study is based on observational methods only and no intervention is carried out by the investigator. Observational studies can be further classified as cohort, case-control and cross sectional (Mann, 2003). In cohort studies a group of the unit of analysis is followed for a longer period of time and data are collected multiple times for each unit. In case-control studies the analyzed entities are matched with a control group. In cross sectional studies only one group is used, data are collected only once, multiple outcomes can be studied and the subjects are assessed to determine whether they were exposed to an intervention (not by the researcher) and whether they have the outcome of interest (Mann, 2003). This paper is utilizing a cross sectional observational design.

Cross sectional studies are used mainly to determine prevalence of a particular phenomenon but are also useful at identifying associations that can then be more rigorously studied using a cohort study or randomized controlled study. The most important limitation of this type of study design is differentiating cause and effect from simple association. The principal summary statistics of cross sectional studies is the odds ratio. Odds ratios are inaccurate when studying rare conditions. This is not a problem in this data set. Also the principal limitation of this design, that is differentiating cause and effect can be mitigated, as is done in this paper, by utilizing theory-based approach when stating the hypotheses. The snapshot approach of the design implies that cross sectional studies use prevalent cases rather than incident cases (newly discovered cases during a period of follow-up), consequently temporal sequence can be difficult to establish, and the information provided can be potentially misleading. Again, this potential danger was minimized by the theory-based approach developed in the previous chapter.

Data and Data Sources

Data are drawn from four sources in order to provide the dependent and a wide selection of independent variables relevant to the study. Data sources are as follows: the

American Hospital Association Annual Survey of Hospitals (AHA) 2003, the Area Resource File 2003 Edition, the Healthcare Cost Report Information System (HCRIS) Dataset 2002 from the Centers of Medicare and Medicaid Services and the Leapfrog Group's Hospital Survey 2003.

The Leapfrog Group provided summary as well as raw survey level data for CPOE related survey questions collected in March 2003. The Leapfrog survey data serve as primary data source for the study. The survey covered hospitals in the first two waves of rollout regions. The CPOE related part of the most recent Leapfrog survey is presented in Appendix B (The Leapfrog Group, 2005). The study hospitals are located in the regions, or their respective Metropolitan Statistical Areas. The first wave included Atlanta (GA), California, Knoxville (TN), Minneapolis (MN), St. Louis (MO), Seattle (WA) and Michigan. The second wave covered Central Florida, Colorado, Dallas-Fort Worth (TX), Kansas City (MO), Wisconsin, Massachusetts, Memphis (TN), New Jersey, New York Metro, Rochester (NY), Savannah (GA) and Wichita (KS). Only urban, Metropolitan Statistical Area hospitals are surveyed. Hospitals that were not explicitly invited in the survey had the possibility to submit returns as well. The data set includes a field that distinguishes between Leapfrog invited and self-selected survey respondents. The database has another field for hospitals' Medicare provider ID for cross-reference with other data sets.

The Leapfrog data set includes entries for 922 invited and 224 self-selected hospitals. Out of the 922 invited hospitals 545 submitted a response, while 377 did not respond. Among the respondents 26 got a score of "Fully Implemented", 77 received

"Good Early Stage Effort", 113 were "Good Progress" and 329 were "Willing To Report But Did Not Meet Leapfrog Criteria". In the group of 224 self-selected hospitals 5 got a score of "Fully Implemented", 34 received "Good Early Stage Effort", 33 were "Good Progress" and 152 did not meet the Leapfrog criteria. It is interesting that the percentage of "Willing To Report But Did Not Meet Leapfrog Criteria" category in the self-selected hospitals is almost as high, 68 percent as the sum of the non-respondents and "Willing To Report But Did Not Meet Leapfrog Criteria" together in the invited group, 76 percent. These preliminary statistics indicate that the sample size for each category will be sufficiently large for the statistical testing to draw meaningful conclusions.

The raw Leapfrog data have answers for the following questions:

1) Does your hospital have functioning CPOE system in at least one part of the hospital? – yes/no
2) Does your hospital require all physicians to enter hospital medication orders via a computer system linked to prescribing error prevention software? – yes/no
3) Does your hospital's CPOE system require documented acknowledgement by the prescribing physician of the interception of potentially serious prescribing errors prior to any override? – yes/no
4) What percent of your hospital's total medication orders are entered by physicians via

a computer system linked to prescribing error prevention software? – percentage

If there was a NO at question number 1 or less than 75 percent at question number 4 then answer for questions number 5-10 is required.

5) If your hospital does not have a CPOE system installed that meets Leapfrog's criteria please indicate your stage of CPOE implementation:
   a) Planning for CPOE.
   b) Currently selecting CPOE system (at a minimum has been written).
   c) Currently implementing a CPOE system.
   d) None of the above.
6) Do you have a written strategy for implementing CPOE? – yes/no
7) Have you defined a timeline and launched a CPOE implementation project? – yes/no
8) What is the date by which your hospital commits to meet fully the Leapfrog CPOE standard? – date as year
9) Has your hospital board approved a dedicated budget for CPOE for the latest fiscal year for which a final budget has been approved? – yes/no
10) Do you have a physician sponsor who leads your CPOE initiative? – yes/no

In addition to the primary Leapfrog database, the American Hospital Association's 2003 Annual Survey will be used as one of the secondary data sources to cross-reference the hospitals' answers to their respective organizational and environmental characteristics. The AHA data are used for references for staffing, operational performance, ownership and other organizational features. The AHA data is also used forinserting control variables into the various statistical algorithms. The AHA database was cleaned for missing data entries. Organizations too many missing data points are not utilized in the data analysis.

The AHA data is also used for operationalizing the environmental pressure by identifying the number of HMOs the hospital contracted with. The AHA data have been used extensively before to obtain specific hospital characteristics in health care management innovation adoption research (Walston and Kimberly, 2001, Burns and Wholey, 1993).

The Area Resource File 2003 Edition serves as other secondary data source. The Area Resource File database is well known source for HMO related information and widely used both in HMO specific and general healthcare management research (Best, 1999 and Feldman and Wholey, 2001). The data set provides the necessary cross-reference for the specific hospitals' environment regarding the HMO market share in the particular Metropolitan Statistical Area after aggregating the county data to the MSA level (Feldman and Wholey, 2001).

The Healthcare Cost Report Information System (HCRIS) dataset serves as the last secondary data source. The HCRIS database of the Centers for Medicare and Medicaid Services provides the data for calculating operating income per admission and case mix index of the hospital.

Measurement of Dependent Variables

Dependent variables are also called outcome variables. Three forms of the dependent variable are used in the study. Two of them are binary, dummy variables and the third is an ordered categorical variable. The binary variables are constructed specifically for the study (based on Leapfrog's scoring criteria) while the categorical variable uses the original Leapfrog scoring algorithm developed and published by

Leapfrog for assessing hospitals' CPOE adoption. (Because the order of the survey questions changed I had to change the referenced question numbers of the scoring algorithm, but other than that the scoring algorithm is the same as Leapfrog's.)

The first binary dependent variable was constructed by lumping together the "Fully Implemented", "Good Progress" and "Good Early Stage Effort" categories of the Leapfrog algorithm and are called summarily as "Adopters" (labeled with one). The "Willing To Report Publicly" and "Did Not Disclose" categories were lumped together as "Non Adopters" (labeled with zero). While creating the above dummy variable, the study assumes that non-respondents are non-adopters. This assumption is one of the limitations of the study. However, based on the theory developed in the previous chapter one can legitimately argue that because of the environmental pressure and competitive forces, hospitals that are in compliance with the Leapfrog initiative are "eager" to report and publicize their "leading edge management practice". Hospitals that are in compliance will submit response to the survey. Consequently, those who did not respond legitimately can be assumed to be non-compliant, that is non-adopters.

The fact that the preliminary analysis of the data shows that among self-selected hospitals the category of "Willing To Report Publicly But Did Not Meet Leapfrog Criteria" is almost as large as the same category and non-respondents together among invited hospitals, indicate that the non-respondents would most likely end up among non-adopters. Assuming of course that the non-respondents are not statistically significantly different from respondents regarding the independent variables.

This assumption will be tested. Also, non-respondents and the group of "Willing To Report Publicly But Did Not Meet Leapfrog Criteria" will be compared to see if there is statistically significant difference in independent variables.

The second binary variable was built to further analyze early and late adopters. This was done to see if there is an organizational difference as reported in some of the innovation management literature or it is missing as reported by others (Walston and Kimberly, 2001 and Westphal et al, 1997 and Arndt and Bigelow, 1995). The categories of "Fully Implemented" and "Good Progress" were lumped together (labeled with 1) as early adopters. The category "Good Early Stage Effort" was defined as late adopters lagging by at least three years (for those reporting at the end of 2002) or four years (for those hospitals participating in the first wave of rollout and submitting surveys in 2001) according to their timeline of CPOE implementation. The late adopters were labeled with zero.

The ordered categorical dependent variable was built by assigning a number between one and four to the various original Leapfrog categories derived from the scoring algorithm. "Fully Implemented" was labeled with four, "Good Progress" was labeled with three, "Good Early Stage Effort" was labeled with two and the "Willing To Report" and "Did Not Disclose" categories were lumped together as "Non-Adopters" and labeled with one. Although this looks as somewhat arbitrary classification, the study argues that the wording of the publicly available Leapfrog algorithm makes clear the intention of the Leapfrog experts.

The publication of the algorithm, as well as the graphical presentation of the summary score findings on the Leapfrog web site and consumer publications emphasize that the summary scores are not simply multinomial categories but are ordered from the best to the worst. Consequently, the study's classification is legitimate and represents the expert opinion of the Leapfrog CPOE Board.

Table 2 presents the constructs, dependent variables, measurements and data source. For all three variables the construct is adoption. The dependent variables are either CPOE adoption, or early/late adoption, or the adoption stage. Measurements of the variables are either one or zero or stages between one and four. Leapfrog is the only data source. One indicates either an adopter hospital or an early adopter hospital. Zero indicates either an non-adopter or a late adopter, for the adopter subset of hospitals. For adoption stages one indicates no adoption, two indicates good early stage effort, three represents good progress and four indicates full implementation of the measures.

Table 2. Study Constructs, Dependent Variables, Measurement and Data Source.

Construct	Dependent Variable	Measurement	Data Source
Adoption	CPOE Adoption	1=Adopter 0=Non-Adopter	Leapfrog
Adoption	Early/Late CPOE Adoption	1=Early Adopter 0=Late Adopter	Leapfrog
Adoption	Stage of CPOE Adoption	4=Fully Implemented 3=Good Progress 2=Good Early Stage Effort 1=Did Not Adopt Yet	Leapfrog

Measurement of Independent Variables

Table 3 presents the independent variables that are also called predictor, determining or explanatory variables. Independent variables came from multiple sources, the American Hospital Association's Annual Survey database to operationalize organizational factors and also from the Area Resource File for environmental characteristics. The Centers for Medicare and Medicaid Services provided the data bases to operationalize the profit margin and the service complexity variables.

Table 3. Study Constructs, Independent Variables, Measurement Level and Data Source.

Construct	Independent Variable	Measurement Level	Data Source
Operational Characteristics	Excess capacity	Hospital	AHA
	Salaried Physicians	Hospital	AHA
	Ownership	Hospital	AHA
	Number of Services Offered	Hospital	AHA
	Complexity of Services Offered	Hospital	CMS
Organizational Characteristics	Community Orientation	Hospital	AHA
	Integrated Delivery Network/System Membership	Hospital	AHA
	Size	Hospital	AHA
Financial Characteristics	Operating Income Per Admission	Hospital	CMS
Environmental Characteristics	HMO Penetration	MSA	ARF
	Number of HMO Contracts	Hospital	AHA
	Herfindahl Index of Hospitals	MSA	AHA

Continuing from Table 3, the independent variables are operationalized in Table 4 and variable definitions are provided. Most of the independent variables and their definitions are self-explanatory and are using the original AHA, ARF or CMS variables. Variables directly used from AHA are Ownership, Physician Staffing, Number of HMO Contracts and Size.

Table 4. Independent Variables and Definitions.

Independent Variable	Variable Definition
Excess Capacity	Continuous: 100 – ((Hospital Unit Inpatient Days/(Hospital Unit Beds * 365)) * 100)
Ownership	Dichotomous: 1=For-Profit; 0=Not-For-Profit
Community Orientation	Continuous: Number of "yes" of six community orientation survey question
Physician Staffing	Dichotomous: Integrated salary model 1=yes; 0=no
Size	Continous: Number of hospital unit beds
Operating Income Per Admission	Continuous: (Net Patient Revenue – Operating Expenses)/Number of Admission
Number of Services	Continuous: Sum of services offered
Complexity of Services	Continuous: Case Mix Index
IDN/System Membership	Dichotomous: 1=yes; 0=no
HMO Penetration Rate	Continuous: HMO penetration rate
Number of HMO Contracts	Continuous: Number of HMOs the hospital contracted with
Herfindahl Index	Continuous: Sum of the squared proportions of hospital inpatient day market share (Market share = Each hospital's share of the total number of inp days

Excess Capacity, Community Orientation, IDN/System Membership, Number of Services Offered and Herfindahl Index are computed using variables of the AHA data set. The Case Mix index of the CMS data was used directly to operationalize the Complexity of Services a hospital offers to its patients. HMO Penetration Rate is calculated from the ARF data by dividing the total MSA population number (aggregated from county level) with the total number of HMO enrollees in the specific MSA (aggregated from county level) and multiplied with one hundred.

Operating Income Per Admission is calculated using the CMS data by subtracting the Operating Expenses from the Net Patient Revenue variable and dividing the result by the number of admissions in the specific hospital. Excess capacity is calculated for each hospital by dividing the total annual inpatient days (AHA variable) with the product of the number of total beds (AHA variable) and the number of days of the year. The result is multiplied with one hundred and subtracted from one hundred. The final result then shows the excess capacity in percentage.

Community Orientation is computed by summing the number of the "yes" (labeled as number one) in the AHA data set of the six questions asking of the community orientation of the hospital. Researchers found that the six questions concerning of six activities related to the generation, dissemination and use of community intelligence were good predictors of the hospital's community orientation (Proenca, Rosko and Zinn, 2000). Number of Services Offered is calculated by adding up the various services reported by the hospital to AHA.

IDN/System Membership was labeled one (yes) if the AHA data set had a positive answer for either a health care system or alliance or network membership question. Finally, the Herfindahl Index was constructed as the sum of squared proportions of hospital inpatient day market share. Market share was defined as each hospital's share of the total number of inpatient days in the specific market, that is MSA. Others used this method in health services research before (Burns, Bazzoli, Dynan and Wholey, 2000).

Control Variables

The last group of variables consists of control variables. Payer mix will be included as percentage of combined Medicare and Medicaid days of the total hospital inpatient days. The AHA database provides the necessary data to calculate the government sponsored inpatient days.

Statistical Methods

Descriptive statistics is used to describe the variables. Frequency is used for categorical (dichotomous and multinomial) variables and means and standard deviation for continuous variables. The various organizational, operational, financial and environmental characteristics of the self-selected respondents will be compared to the invited respondents to provide details of the data set. Univariate analysis will be used when necessary to gain further insights in the variables. Student t-tests and ANOVA are applied for continuous independent variables for groups defined by dichotomous and multinomial dependent variables.

In the main part of the analysis multivariate analysis will be utilized to answer the research questions. Because the dependent variable is either dichotomous or ordinal categorical a simple linear or called otherwise, ordinary least squares regression would be a wrong choice (Daniel, 1999). Binomial logistic regression will be used when the dependent variables are dichotomous and ordinal logistic regression model will be used when the dependent variable is ordinal categorical in nature. Logistic regression is used before extensively in health services research on hospitals in general as well as in management innovation adoption in particular (Kwak and Clayton-Matthews, 2002, McCue and Clement, 1996, Castle, 2001, Burns and Wholey, 1993). Odds ratios, probabilities, test of significance and model fits will be provided. The study uses SPSS to calculate the statistics.

In logistic regression the researcher directly estimates the probability of an event occurring. For more than one independent variable, the model is described as:

$Prob(event) = 1/(1+e^{-Z})$

$Z = B_0 + B_1X_1 + B_2X_2 + \dots + B_pX_p$

B: Coefficients estimated from the data

X: Independent variable

p: Number of independent variables

e: Base of natural logarithm (2.718)

Prob(event): Predicted probability that an event occurs

The relationship between the independent variable and the probability is nonlinear. The probability estimate is always between zero and one, regardless of the value of Z. The only assumptions that are needed are that the observations are independent and that the model is correctly specified. That is, all necessary independent variables are included and the relationship between each of the variables and the log of the ratio of the probability that an event occurs to the probability that it does not occur is linear. The logistic regression model is a very flexible tool for studying the relationship between a set of variables that can be continuous or categorical and a categorical outcome. In logistic regression, the parameters of the model are estimated using the maximum-likelihood method. The coefficients that make the observed results most likely are selected. Because the logistic regression is nonlinear an iterative algorithm is used for parameter estimation.

In multiple linear regression the interpretation of the regression coefficient is straightforward. It is the estimated change in the dependent variable for one-unit change in the independent variable while the values of the other independent variables are held constant. The interpretation of the coefficient of the logistic regression is not as intuitive. To interpret the results of the logistic regression the Odds will be calculated. The odds of an event occurring is defined as the ratio of the probability that an event occurs to the probability that it does not. For example, for this study the odds that a hospital is CPOE adopter can be described as:

Odds = Prob(CPOE Adopter)/Prob(CPOE Non-Adopter)

The logistic equation can also be written in terms of odds as:

Prob(Adoption)/Prob(Non-Adoption) = $e^{B0+B1X1+ \dots + BpXp}$

This means that e raised to the power B_i is the factor by which the odds change when the ith independent variable increases by one unit and all of the other variable values stay the same. This is also called the odds ratio. If B_i is positive then the odds ratio is greater than 1 that is the odds of the CPOE adoption are increased. If B_i is negative then the odds ratio is less than one, which means that the odds of CPOE adoption are decreased. If B_i is zero then the odds ratio equals one and the odds are unchanged. The odds ratios will be calculated for the various independent variables in the model to test CPOE adoption in individual hospitals. 90 percent confidence interval ($p= 0.1$) will be used to see what odds ratio coefficients are statistically significant findings. If the interval will include the value one (no change in odds) we will not be able to conclude, based on this sample of data, that a unit change in the particular independent variable is associated with a change in the odds of CPOE adoption while all other variables are held constant.

In case of logistic regression it is customary to use (–2) times the log of the likelihood (-2LL) as a measure of how well the estimated model fits the data. A good model results in a high likelihood of the observed results which means a small value for the –2LL. The change in the likelihood value is used to determine how the fit of a model changes as variables are added or deleted from the model. The statistics to look for is the change in the –2log-likelihood. The likelihood ratio statistics is defined as:

Likelihood-ratio = -2LL(reduced model) – (-2LL(full model)). For sufficiently large sample size the likelihood-ratio statistic has a chi-square distribution with k degrees of freedom, where k is the difference between the number of parameters in the two models. The null hypothesis that the likelihood ratio tests is that the coefficients of the terms that are excluded from the full model are 0 (Norusis, 2003).

Limitations

The analytical approach presented in this chapter has limitations that are related to the study design, data used, variable measures and statistical procedures applied. The most important limitation of the cross-sectional observational design is differentiating cause and effect from simple association. Applying theory based framework and model development mitigates this limitation. In cross-sectional studies temporal sequence can be difficult to establish and the information provided can be potentially misleading. Again, this danger was minimized by the theory based hypothesis development.

Using Leapfrog's survey data as data source limits the study to analyze only Metropolitan Statistical Areas, and urban hospitals. Rural hospitals are not represented in the analyzed sample. Generalization could be difficult because of this limitation. In addition, only the first two waves of Leapfrog rollouts are analyzed.

Although preliminary descriptive statistics suggests that the percentage of non-adopters in the self-selected group of hospitals almost equals the total percentage of reported non-adopters (hospitals that submitted a survey and were scored to be non-adopters) and non-respondents, classifying non-respondents as non-adopters carries risk. A thorough comparison of the reported non-adopter, non-respondent and non-adopter self-selected groups will reveal if the classification assumption (while developing one of the dependent variables) is problematic or not. Use of logistic regression requires that the observations should be independent and the model correctly specified. As the model was developed on the foundation of a theory basis, this limitation is mitigated.

Summary

Chapter 4 described the research design, data sources, dependent and independent variables as well as the statistical methods used in the paper. Various univariate and multivariate statistical techniques are used to discover potential association between internal and external factors and hospital's decision to adopt CPOE system.

The study design is observational, cross-sectional design to analyze hospital's decision to adopt CPOE systems as reflected in the Leapfrog survey at the end of 2002. Since the study is using dichotomous and ordinal multinomial categorical variables as dependent variables the multivariate statistical methods are various forms of logistic regressions. Logistic regression is used to test all the hypotheses and the association of hospitals' CPOE adoption decision.

Chapter 5 presents the results of the study and Chapter 6 presents the discussions, implications, limitations and suggestions for future research.

Chapter 5: RESULTS

This chapter provides the findings of the statistical methods described in Chapter 4. First, results of the descriptive statistics of the dependent and independent variables will be presented for the full database (invited respondents, non-respondents, self-respondents). Next, the findings of the univariate analyses will be shown for the full database. If there is a statistically significant difference between these groups in independent variables, then separate analyses will be presented for the invited respondent group, and the self-respondents and non-respondents will not be part of the study population for the rest of the descriptive statistics, the univariate and multivariate analyses.

Outliers and Missing Values

Cases with outlier values for Excess Capacity, Number of Services Offered, Operating Income Per Admission, Case Mix Index, Number of HMO Contracts and Size were removed from the database. One common way of defining outliers is to find the mean and standard deviation of the data set and then call anything that falls more than three standard deviations away from the mean an outlier. This method is called the z-test in statistics. The z-test was used for the study database to eliminate outliers.

A reasonableness check of the data was also performed to make sure that the actual values made sense. For example, hospitals with zero reported bed size or zero number of services were deleted from the database. Similarly, hospitals with negative excess capacity were deleted. Values for HMO Penetration Rate, Herfindahl Index and Community Orientation either did not have outlier values or were very close to the acceptable range, so cases were not eliminated based on these three variables. Ninety-five cases were deleted based on values for Size, two based on Number of HMO Contracts, seven based on Case Mix Index, five based on Operating Income Per Admission, 20 based on Number of Services, and 15 based on Excess Capacity. This left 1,006 hospitals out of 1,150 original study hospitals.

Missing values were not substituted to preserve the data as much as possible in its original form. Out of the 1,006 hospitals, Size had valid values for 916, HMO Penetration Rate had 816, Excess Capacity 916, Number of Services Offered had 826, Operating Income Per Admission had 893, Case Mix Index had 936, Number of HMO Contracts had 663, Herfindahl Index had 831, System Membership had 849, Salaried Physician had 826, Community Orientation had 748 and Ownership had 803 valid values. With the exception of Number of HMO Contracts (66 percent valid) and Community Orientation (74 percent valid), all other variables had at least 80 percent valid (non-missing) values.

There are methods to substitute missing values in data analysis. One method widely used is to substitute any missing value with the mean value for the specific variable. The mean is calculated by using the non-missing data points for the variable.

As it will be reported later in the chapter, substituting the missing values with averages for the individual variables did not change the results for the specific analysis. This was true regarding both the number of statistically significant findings as well as the level of significance of the findings.

Descriptive Statistics of Dependent Variables for the Combined Population

Table 5 shows the results of the frequency statistics of Adopter and Non-Adopter hospitals. There are 266 adopter hospitals and 736 non adopter organizations. There are four hospitals with missing values for a total of 1006 hospitals.

Table 5. Frequency Distribution of Adopters

	Frequency	Percent
Adopter	266	26
Non-Adopter	736	73
Missing	4	0.4
Total	1006	100

26 percent of the database hospitals are categorized as Adopters. 73 percent of the submitting organizations are Non-Adopters. Less than half percent of the hospitals have missing values for adoption status. As mentioned 1006 hospitals complies the 100 percent sample.

Table 6 presents the distribution of the stage of adoption status. There are 159 hospitals that are early adopters and 107 organizations that are late adopters. The total number of hospitals adds up to 266. The table shows the actual frequency values for the Early Adopter and Late Adopter organizations. The table also presents the percentage distribution of the two categories.

Table 6. Frequency Statistics of Adoption Stage

	Frequency	Percent
Early Adopter	159	60
Late Adopter	107	40
Total	266	100

Forty percent of the organizations are classified as Late Adopters. As mentioned earlier the 266 hospitals compile the 100 percent of the sample. This is a surprise.

Table 7 shows the distribution of the ordered categorical dependent variable. Twenty nine hospitals are full implementers. Good progress is seen in 130 organizations and 107 are in good early stage. There are 736 non adopter hospitals.

Table 7. Frequency Distribution of Ordered Dependent Variable

	Frequency	Percent
Fully Implemented	29	2.9
Good Progress	130	12.9
Good Early Stage	107	10.6
Non-Adopter	736	73.2
Missing	4	0.4
Total	1006	100

The results show that 2.9 percent of the study hospitals are full implementers of the CPOE initiative (as can be expected from the literature). Nearly 13 percent shows good progress, and nearly 11 percent is at good early stage (Leapfrog criteria of classification). The table presents the frequency and percentage statistics for the various groups of hospitals. Four groups are studied and presented in the table. The groups are: hospitals that are fully implementing, hospitals that are showing good progress, hospitals in good early stage and non-adopters.

Table 8 presents the distribution of Adopters versus Non-Adopters in light of their status as Invited (926) or Self-Reporting (224) hospitals. There are 197 invited adopter.

Table 8. Frequency Statistics of Adoption Stage Per Survey Invitation Status

		Adopters	Non-Adopters
Invited	Frequency	197	588
	Percent	25	75
Self-Reported	Frequency	69	148
	Percent	32	68

The results show that a higher percentage of self-reporting hospitals is classified as Adopter than in cases of invited hospitals--32 percent versus 25 percent. The seven percent difference could be the consequence of aggregating the "Willing To Report Publicly But Did Not Meet Leapfrog Criteria" with the "Did Not Disclose" group in case of Invited hospitals. That is, the Invited hospitals that did not return the survey are classified as Non-Adopters, a possibly false negative classification.

Table 9 shows the distribution of Early and Late Adopters by Invited versus Self-Reporting hospital groups. The table indicates that about ten percent more of the invited hospitals can be classified as early adopter compared to the self-reporting hospitals.

Table 9. Early and Late Adopters by Invitation Status

		Early Adopter	Late Adopter
Invited	Frequency	123	74
	Percent	62	38
Self-Reported	Frequency	36	33
	Percent	52	48

Table 10 presents the findings of the frequency distribution of the ordered dependent variable based on survey invitation status. As the results show, 3 percent of the invited hospitals are in the Fully Implemented category versus 2 percent of the self-reporting hospitals. Thirteen percent of the invited hospitals are in the Good Progress, and 9 percent are in the Good Early Stage Effort categories compared to 14 and 15 percent of the self-reporting hospitals. As noted earlier, 75 percent of the invited hospitals compared to 68 percent of the self-reporters are classified as Non-Adopters. There are 588 non adopter invited and 148 non adopter self reporting organizations.

Table 10. Frequency Distribution of Ordered Dependent Variable by Invitation Status

		Fully Implemented	Good Progress	Good Early Stage	Non-Adopter
Invited	Frequency	24	99	74	588
	Percent	3	13	9	75
Self-Reported	Frequency	5	31	33	148
	Percent	2	14	15	68

Table 11 presents the frequency distribution of the original Leapfrog classifications by invitation status. As the results indicate, 38 percent of the invited hospitals submitted an empty survey or did not submit a survey at all. Obviously, this category is zero percent for self-reporting hospitals. Thirty-six percent of the invited hospitals ended up in the "Willing To Report Publicly But Did Not Meet Leapfrog Criteria" category. For self-reporting hospitals, this category comprises 68 percent of the organizations. There are 24 full implementer and 99 good progress hospitals in the invited group. Seventy-four hospitals are in a good early stage in the invited group.

Table 11. CPOE Summary Statistics by Survey Invitation Status

		Invited	Self-Reported
Fully Implemented	Frequency	24	5
	Percent	3	2
Good Progress	Frequency	99	31
	Percent	13	14
Good Early Stage	Frequency	74	33
	Percent	9	15
Willing To Report	Frequency	285	148
	Percent	36	68
Did Not Disclose	Frequency	303	0
	Percent	38	0.0

Descriptive Statistics of Independent Variables

Table 12 shows the frequency distribution for the dichotomous independent variables while table 13 presents the descriptive statistics for the continuous independent variables for the combined population of invited and self-reporting hospitals as well as the two groups separately. As table 12 shows, the combined population of hospitals is very similar to the invited subgroup regarding the three analyzed independent variables. The reason is partly that the self-reported group itself is similar to the invited group and partly that the self-reported group is a relatively small proportion of the combined population. Twenty-seven percent of invited hospitals have salaried physicians versus 33 percent of the self-reporting hospitals. Eighty-three percent of invited hospitals are system or network members compared to 82 percent of self-reporting hospitals. The only difference that seems to be substantial is in the ownership status of the two groups. Sixteen percent of the invited hospitals are for profit while 43 percent of the self-reporting organizations are for profit.

Table 12. Frequency (Percentage) Distribution of Selected Independent Variables

	Combined	Invited	Self-Reported
Salaried Physician Yes	231 (28)	172 (27)	59 (33)
Salaried Physician No	595 (72)	476 (73)	119 (67)
Not For Profit	630 (79)	538 (84)	92 (57)
For Profit	173 (21)	104 (16)	69 (43)
System Membership Yes	703 (83)	551 (83)	152 (82)
System Membership No	146 (17)	113 (17)	33 (18)

Table 13 shows the basic descriptive statistics of the continuous independent variables. The invited group of hospitals has a 36 percent HMO penetration rate with an average excess capacity of 33 percent, is offering 53 services, and has an operating income per admission of –18 dollars. The self-reporting hospitals have a much lower penetration rate of 24 percent, a higher excess capacity of 39 percent, and are offering almost the same number of services. Size, case mix index and community orientation are 282 beds, 1.39 and 5 for invited hospitals versus 232, 1.35 and 5 for self-reporting.

Table 13. Mean (Standard Deviation) of Continuous Independent Variables for Invited and Self-Reporting Hospitals and Combined Group

	Combined	Invited	Self-Reported
HMO Penetration Rate	33.96 (13.11)	35.76 (12.30)	23.51 (12.69)
Excess Capacity	33.96 (15.42)	32.69 (14.60)	38.70 (17.41)
Number of Services Offered	52 (22)	53 (22)	48 (23)
Operating Income/Admission	-7.64 (124.21)	-17.63 (125.12)	28.37 (114.12)
Case Mix Index	1.38 (0.24)	1.39 (0.23)	1.35 (0.26)
Herfindahl Index	0.22 (0.26)	0.16 (0.18)	0.61 (0.32)
Number of HMO Contracts	13 (15)	14 (16)	7.66 (5.88)
Community Orientation	5.15 (1.43)	5.21 (1.41)	4.93 (1.50)
Size	271 (229)	282 (230)	232 (218)

Invited hospitals have a much higher number of HMO contracts--14 versus 8--and a lower Herfindahl index--0.16--compared to 0.61. On the other hand, the self reporting group has a positive operating income per admission on average, compared to the negative operating income per admission of the invited hospitals, $28.37 versus minus $17.63.

One other interesting question is how comparable are the independent variables between the group of invited reporting hospitals (482 hospitals or 61 percent) and the invited but not reporting hospitals (303 hospitals or 39 percent). Table 14 presents the findings for the invited reporting versus the invited but not reporting groups. These findings show the distribution of the dichotomous independent variables.

Table 14. Frequency (Percentage) Distribution of Dichotomous Independent Variables for Invited Reported vs. Invited Did Not Respond Hospitals

	Reported	Did Not Respond
Salaried Physician Yes	129 (31)	43 (19)
Salaried Physician No	286 (69)	190 (81)
Not For Profit	361 (89)	177 (76)
For Profit	47 (11)	57 (24)
System Membership Yes	365 (85)	186 (80)
System Membership No	67 (15)	46 (20)

Thirty-one percent of hospitals that were invited and submitted surveys had salaried physicians on staff. Eighty-nine percent were not for profit, and 85 percent had system or network membership. On the other hand, hospitals that did not respond to the survey invitation were system or network members in 80 percent of the cases.

They had salaried physician staff in 19 percent of the cases. 76 percent of them were not for profit.

Table 15 shows the results for the continuous variables for the invited reporting and invited non-reporting groups. Hospitals that returned surveys had (on average) a 36 percent HMO penetration rate and a 32 percent excess capacity, offered 56 services, had –20 dollars operating income per admission, and had 303 beds. Organizations that did not return the Leapfrog survey had a 35 percent HMO penetration rate in their market area, had a 34 percent excess capacity, offered eight fewer services, and had a somewhat better operating income per admission, - 18 dollars on 246 beds on average. The rest of the variables had very similar statistics for both groups. For respondent hospitals, the case mix was 1.42 (1.33 for non-respondents), the Herfindahl index was 0.16 (0.15), the number of HMO contracts was 14, and community orientation had a score of 5.31 (5.04).

Table 15. Mean (Standard Deviation) of Continuous Independent Variables for Invited Reported vs. Invited Did Not Respond Hospitals

	Reported	Did Not Respond
HMO Penetration Rate	36.11 (13.04)	35.18 (10.94)
Excess Capacity	32.19 (14.15)	33.52 (15.31)
Number of Services Offered	56 (23)	48 (19)
Operating Income/Admission	-19.49 (122.52)	-17.61 (129.43)
Case Mix Index	1.42 (0.24)	1.33 (0.21)
Herfindahl Index	0.16 (0.17)	0.15 (0.20)
Number of HMO Contracts	14 (18)	14 (13)
Community Orientation	5.31 (1.36)	5.04 (1.50)
Size	303 (247)	246 (195)

The next section shows the results of investigating whether or not the groups of self-reporting, invited responding, and invited not-responding hospitals are statistically significantly different in the independent variables. Also, analysis will be done to ascertain if there is any statistically significant difference in the responses of self-reporting versus invited (and responding) hospitals.

Univariate Analyses for the Combined Population

Table 16 presents the results for cross tabulations for the three categorical variables: Salaried Physician, Ownership and System Membership. The three groups analyzed are: self-reporting, invited responding, and the invited not responding organizations.

Table 16. Cross tabulation Chi-Square Results for Categorical Independent Variables by Invited Respondents, Non-Respondents and Self-Reporting Hospitals

	Pearson Chi-Square	df	Significance (2-Sided) for Chi-Square	Lambda for Row Variable	Approximate Significance For Lambda
Salaried Physician	14.84	2	0.001	0.000	0.000
Ownership	68.62	2	0.000	0.056	0.041
System Membership	2.05	2	0.360	0.000	0.000

The table indicates that being in the category of invited respondent, non-respondent or self-reporting hospital is independent from the System Membership variable status. The Pearson Chi-square value is low--2.05--and it is not statistically significant with p a value of 0.36. The directional measure of Lambda is zero for System Membership as expected from the Chi-square finding.

The table shows that falling into any of the two categories of Salaried Physician (salaried physician on staff or not) is not independent from falling into any of the categories of invited respondents, non-respondents or self-reporting hospitals. The Pearson Chi-square has a value of 14.84 and a highly significant p value of less than 0.005. However, the significant Chi-square value is not associated with significant Lambda directional measure and is probably the consequence of the relatively large sample size.

On the other hand, falling into any of the two categories of Ownership is not only not independent from being in any of the three categories of response groups with a high Chi-Square value, but it also produces a statistically significant Lambda directional measure as well. The Pearson Chi-square for Ownership is 68.62 with a p value of significance of less than 0.005. The Ownership variable also has a statistically significant ($p = 0.041$) Lambda statistics (0.056). That is, knowing the category of ownership reduces the prediction error by 5.6 percent when predicting the categories of response status (invited respondent, non-respondent or self-reporting).

Table 17 shows the expected and actual cross tabulation frequencies for the Ownership variable. Among non respondents there are 50 for-profit hospitals. Among self-respondents there are 35 for-profit organizations. Eighty eight of the invited respondents are for profit. There are 184 not for profit non-respondent and 126 not for

Table 17. Expected and Actual Counts, Response Status by Ownership /Expected (Actual)/

	For-Profit	Not-For-Profit
Non-Respondent	50 (57)	184 (177)
Self-Respondent	35 (69)	126 (92)
Invited Respondent	88 (47)	320 (361)

profit self-respondent organizations in the sample. There are 320 invited respondent hospitals who are not for profit. For profit and not for profit hospitals are shown.

The results paint a somewhat mixed picture. For-profit hospitals, if invited, are more likely to fall into the non-respondent category than not-for-profit hospitals. On the other hand, for-profit hospitals are more likely to take the initiative and become a self-reporting organization than not-for-profit hospitals. Of course, the error reduction in prediction is not too high, only 5.6 percent as indicated above.

Table 18 presents the results of ANOVA for the independent variables when grouped by the response status (invited respondent, non-respondent and self-reporting). Results for F-statistics and their significance levels are presented. The degree of freedom is two for all groups. The table shows the F-statistics for ANOVA results. The accompanying degree of freedom is also presented. In addition, the levels of significance are shown for each individual independent variable. The independent variables are the HMO penetration rate, the excess capacity, the number of services offered, the operating income per admission. The other variables are the case mix index, the Herfindahl index, number of HMO contracts, community orientation and size measured in number of beds.

Table 18. ANOVA Results for Continuous Independent Variables by Invited Respondents, Non-Respondents and Self-Reporting Hospitals

	F Statistics	df	Significance
HMO Penetration Rate	50.611	2	0.000
Excess Capacity	12.549	2	0.000
Number of Services Offered	15.035	2	0.000
Operating Income/Admission	10.774	2	0.000
Case Mix Index	15.858	2	0.000
Herfindahl Index	243.338	2	0.000
Number of HMO Contracts	11.384	2	0.000
Community Orientation	4.835	2	0.008
Size	9.124	2	0.000

As the results indicate, there is a statistically significant difference (p value < 0.05) between the groups for all of the variables. HMO Penetration Rate, Excess Capacity, Number of Services Offered, Case Mix Index, Herfindahl Index, Number of HMO Contracts, Community Orientation, Operating Income per Admission and Size all have statistically significant differences ($p < 0.05$) among at least some of the groups according to the ANOVA F statistics.

Table 19 shows the results of the Bonferroni method for pairwise comparison of the ANOVA means. The goal of the analysis is to find what means differ significantly from others among the groups. This helps to put into perspective the ANOVA findings. The table shows the response category as non-respondents, self-respondents and invited-respondents. The mean difference for each independent variables is calculated by distracting the mean for the specific independent variable for the specific respondent group from the mean of the other respondent group.

Table 19. Bonferroni Method of Multiple Comparisons for Independent Variables by Response Status

	Response Category I	vs Response Category J	Mean Difference (I-J)	p	95 CI (Lower/ Upper)	
HMO Pen Rate	Non-Respondent	Self-Respondent	11.67*	0.0	8.99	14.36
		Invited Respondent	-0.92	0.3	-2.83	0.98
	Self-Respondent	Invited Respondent	-12.60*	0.0	-15.10	-10.09
Excess Capacity	Non-Respondent	Self-Respondent	-5.17*	0.0	-7.99	-2.36
		Invited Respondent	1.33	0.3	-0.97	3.63
	Self-Respondent	Invited Respondent	6.51*	0.0	3.94	9.07
Number of Services	Non-Respondent	Self-Respondent	-0.65	0.8	-4.96	3.65
		Invited Respondent	-8.68*	0.0	-12.22	-5.14
	Self-Respondent	Invited Respondent	-8.03*	0.0	-11.91	-4.15
Operating Income/ Admission	Non-Respondent	Self-Respondent	-42.99*	0.0	-65.76	-20.22
		Invited Respondent	4.88	0.6	-13.91	23.67
	Self-Respondent	Invited Respondent	47.86*	0.0	27.03	68.70
Case Mix Index	Non-Respondent	Self-Respondent	-0.02	0.3	-0.067	0.018
		Invited Respondent	-0.094*	0.0	-0.129	-0.060
	Self-Respondent	Invited Respondent	-0.070*	0.0	-0.11	-0.031
Herfindahl Index	Non-Respondent	Self-Respondent	-0.46*	0.0	-0.51	-0.42
		Invited Respondent	-0.013	0.4	-0.045	0.019

Table 19 Continued

	Self-Respondent	Invited Respondent	0.45*	0.0	0.41	0.49
Community Orientation	Non-Respondent	Self-Respondent	0.119	0.4	-0.18	0.41
		Invited Respondent	-0.262*	0.0	-0.50	0.02
	Self-Respondent	Invited Respondent	-0.38*	0.0	-0.64	-0.12
Size	Non-Respondent	Self-Respondent	13.87	0.5	-28.03	55.77
		Invited Respondent	-57.37*	0.0	-91.61	-23.13
	Self-Respondent	Invited Respondent	-71.24	0.0	-109.3	-33.11
Number of HMO Contracts	Non-Respondent	Self-Respondent	6*	0.0	2.71	9.29
		Invited Respondent	-1.14	0.4	-3.79	1.50
	Self-Respondent	Invited Respondent	-7.14*	0.0	-10.11	-4.17

Mean differences with stars indicate statistically significant group difference in the means of the specific independent variable at $p < 0.05$ in Table 19. Non-respondents and invited respondents have a higher HMO market penetration rate than self-respondents. Self-respondents have a higher excess capacity than either non-respondents or invited respondents. Invited respondents offer more services than non-respondents or self-respondents. Invited respondents have a higher case mix index than either non-respondents or self-respondents. Self-respondents have a higher Herfindahl index than non-respondents or invited respondents. Invited respondents have a higher community orientation score than self-respondents or non-respondents.

Invited respondents have a higher bed size than non-respondents. Self-respondents have a lower number of HMO contracts than either non-respondents or invited respondents.

Table 20 shows the results of the homogeneity of variance tests for the independent variables. ANOVA can be used when some assumptions about the data are valid. One of them is that the populations are normally distributed. The other assumption is that the variations of the populations are equal. The third assumption is that the observations are independent. These results show that the assumption of equal variances across groups is violated for six variables and the hypothesis of equal variances rejected.

Table 20. Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Significance
HMO Penetration Rate	4.825	2	813	.008
Excess Capacity	8.874	2	913	.000
Number of Services Offered	1.944	2	823	.144
Operating Income/Admission	.056	2	890	.946
Case Mix Index	11.796	2	933	.000
Herfindahl Index Hospital	61.084	2	828	.000
Community Orientation	2.421	2	745	.090
Size	4.524	2	913	.011
Number of HMO Contracts	9.235	2	660	.000

Table 21 presents the findings for the test of normality of population distribution. As the results show, the null hypothesis for normal population distribution should be rejected in each tested variable (except Number of Services Offered) for all groups at level 0.05.

Table 21. Kolmogorov-Smirnov Tests of Normality

	Response Status	Statistic	df	p
HMO Penetration Rate	0	.123	259	.000
	1	.116	120	.000
	2	.064	437	.000
Excess Capacity	0	.061	268	.016
	1	.071	194	.018
	2	.066	454	.000
Number of Services Offered	0	.055	233	.082
	1	.116	178	.000
	2	.109	415	.000
Operating Income Per Admission	0	.184	266	.000
	1	.168	194	.000
	2	.146	433	.000
Case Mix Index	0	.101	282	.000
	1	.093	195	.000
	2	.101	459	.000
Number of HMO Contracts	0	.240	188	.000
	1	.149	134	.000
	2	.239	341	.000
Herfindahl Index	0	.270	267	.000
	1	.201	120	.000
	2	.232	444	.000
Community Orientation	0	.304	205	.000
	1	.276	160	.000
	2	.380	383	.000
Size	0	.138	268	.000
	1	.168	194	.000
	2	.126	454	.000
System Membership	0	.492	232	.000
	1	.501	185	.000
	2	.511	432	.000
Salaried Physicians	0	.498	233	.000
	1	.427	178	.000
	2	.438	415	.000
Ownership	0	.471	234	.000
	1	.377	161	.000
	2	.526	408	.000

0: Non-Respondent, 1:Self-Respondent, 2: Invited Respondent

Table 22 shows the results of the Kruskal-Wallis test. Because both the normality of distribution and the equal variances assumptions are violated, a non-parametric version of the ANOVA procedure was performed. The Kruskal-Wallis test is a non-parametric version of the one-way analysis of variance for independent samples, calculated based on the sums of the ranks of the combined groups.

Table 22. Kruskal-Wallis Test for Continuous Independent Variables by Invited Respondents, Non-Respondents and Self-Reporting Hospitals

	Chi-Square	df	Significance
HMO Penetration Rate	84.466	2	.000
Excess Capacity	19.065	2	.000
Number of Services Offered	36.588	2	.000
Operating Income/Admission	35.489	2	.000
Case Mix Index	30.000	2	.000
Herfindahl Index	203.729	2	.000
Number of HMO Contracts	45.118	2	.000
Community Orientation	16.653	2	.000
Size	27.028	2	.000

As the results indicate, all the Chi-square values are highly ($p < 0.005$) statistically significant for all the studied variables. According to the non-parametric version of ANOVA, all variables are different across the three response groups of invited respondents, non-respondents and self-respondents.

Table 16 on page 103 shows that the Salaried Physician and Ownership dichotomous variables of the three categorical variables are statistically significantly different across the three response categories. The Kruskal-Wallis procedure presented in Table 22 on page 111 shows by the response status that all the continuous variables are statistically significantly different.

Consequently, the self-respondents cannot be part of the same study population when the invited hospitals are analyzed. In addition, classifying the non-respondents as non-adopters and including them in the same analysis with the invited respondents would result in false findings.

Descriptive Statistics and Univariate Analyses of Invited Respondents

Table 23 shows the frequency distribution of Adopter versus Non-Adopter, Early and Late Adopter, and the ordered categorical adoption stage variables within the group of 482 hospitals that returned the Leapfrog survey.

Table 23. Frequency Distribution of Dependent Variables within the Invited Respondent Group

	Count/Percent	Count/Percent	Count/Percent
Non-Adopters	285 (59)		
Adopters	197 (41)		
	482 (100)		
Early Adopter		123 (62)	
Late Adopter		74 (38)	
Table 23 Continued			
		197 (100)	
Fully Implemented			24 (5)
Good Progress			99 (21)
Good Early Stage			74 (15)
Willing To Report			285 (59)
			482 (100)

There are 197 Adopter hospitals (41 percent of the population) and 285 Non-Adopter hospitals (59 percent) in the sample of 482 hospitals. One hundred and twenty-three organizations, or 62 percent of the Adopters, are Early Adopters while 38 percent, or 74 hospitals, are Late Adopters. Twenty-four hospitals (5 percent of the study population) are in the category of Fully Implemented while 99 hospitals (21 percent) are in the Good Progress category. Seventy-four hospitals (15 percent) belong to the Good Early Stage Effort category while 285 (59 percent) are in the Willing To Report But Did Not Meet Leapfrog Criteria class. (This study population does not include any organizations that did not respond to the Leapfrog survey.)

Table 24 shows the results for the cross tabulation of the dichotomous variables by Adopters versus Non-Adopters. Only the Salaried Physician variable has a statistically significant Chi-square value at level 0.05, but its Lambda directional measure is zero. Ownership and System Membership have no statistically significant Chi-square measure at level 0.05 or 0.1. Falling into Adopter or Non-Adopter categories is independent of being in any of the dichotomous categories of the three categorical variables. These results show the Pearson Chi-square statistics and the two sided significance for the chi-square values as well as the lambda results.

Table 24. Cross tabulation Chi-Square Results for Categorical Independent Variables by Adopter Versus Non-Adopter Hospitals

	Pearson Chi-Square	df	Significance (2-Sided) for Chi-Square	Lambda for Row Variable	Approximate Significance For Lambda
Salaried Physician	5.388	1	0.020	0.000	0.000
Ownership	0.899	1	0.343	0.000	0.000
System Membership	0.212	1	0.645	0.000	0.000

Table 25 presents the cross tabulation results for Early and Late Adopter categories. Again, the Pearson chi-square and the two sided significance statistics are shown. Also, the lambda for row variable is presented wit approximate significance.

Table 25. Cross tabulation Chi-Square Results for Categorical Independent Variables by Early Adopter Versus Late Adopter Hospitals

	Pearson Chi-Square	df	Significance (2-Sided) for Chi-Square	Lambda for Row Variable	Approximate Significance For Lambda
Salaried Physician	2.307	1	0.129	0.000	0.000
Ownership	5.023	1	0.025	0.081	0.060
Sys Membership	0.037	1	0.847	0.000	0.000

Only the Ownership variable has a statistically significant Chi-square value at level 0.05, but its Lambda directional measure (0.081) is not significant at 0.05 level (p=0.060). It is significant at 0.1 level. Salaried Physician and System Membership variables have no statistically significant Chi-square measure at level 0.05 or 0.1. Falling into Early Adopter or Late Adopter categories is independent of being in any of the dichotomous categories of the three categorical variables.

Table 26 presents the findings of ANOVA F-statistics by Adopters versus Non-Adopters. Values of F-statistics as well as their levels of significance are presented. The degree of freedom is one for each groups. Results for all continuous variables are shown.

Table 26. ANOVA Results for Continuous Independent Variables by Adopter and Non-Adopter Hospitals

	F Statistics	df	Significance
HMO Penetration Rate	.669	1	.414
Excess Capacity	21.501	1	.000
Number of Services Offered	9.231	1	.003
Operating Income/Admission	.222	1	.638
Case Mix Index	26.009	1	.000
Herfindahl Index	6.342	1	.012
Number of HMO Contracts	2.202	1	.139
Community Orientation	.543	1	.462
Size	17.136	1	.000

The results for ANOVA in this case are the same as they would be for t-statistics because there are two categories only, Adopter or Non-Adopter. Excess Capacity, Number of Services Offered, Case Mix Index and Size have large F-values and high significance levels, $p < 0.005$. Herfindahl Index is also statistically significantly different, although on a lower significance level, $p < 0.05$. Four of the variables--HMO Penetration Rate, Operating Income Per Admission, Number of HMO Contracts and Community Orientation--do not show any statistically significant difference between the Adopter and Non-Adopter group means.

Table 27 shows the actual means for the Adopter and Non-Adopter groups for each continuous independent variable. As the table shows, Non-Adopters have a higher HMO market penetration rate and higher excess capacity, offer fewer services, have a lower case mix index and bed size, and have a higher Herfindahl index than Adopters. Non-Adopters have a higher HMO market penetration rate and higher excess capacity, offer fewer services.

Table 27. Means of Independent Variables by Adopters And Non-Adopters

	Adopters	Non-Adopters
HMO Penetration Rate	35.45	38.25
Excess Capacity	28.17	34.79
Number of Services Offered	59.36	48.46
Operating Income/Admission	-12.71	-15.74
Case Mix Index	1.52	1.39
Number of HMO Contracts	16.25	16.10
Herfindahl Index	0.14	0.17
Community Orientation	5.33	5.27
Size	347	236

Table 28 presents the results for homogeneity of variance. Excess Capacity, Case Mix Index, Herfindahl Index and Operating Income Per Admission variables violate the equal variances assumption at $p <= 0.05$ level. Results for the Levene statistics are shown. In addition to Levene statistics the significance level of findings is indicated as well. The degree of freedom is one for all groups.

Table 28. Test of Homogeneity of Variances – Invited Only Hospitals

	Levene Statistic	df1	df2	Significance
HMO Penetration Rate	.632	1	435	.427
Excess Capacity	3.856	1	452	.050
Number of Services Offered	1.492	1	413	.223
Operating Income/Admission	3.966	1	431	.047
Case Mix Index	14.483	1	457	.000
Herfindahl Index Hospital	16.818	1	442	.000
Community Orientation	.154	1	381	.695
Size	3.535	1	452	.061
Number of HMO Contracts	3.419	1	339	.065

Table 29 shows the findings for testing the normality of the independent variables. The Kolmogorov-Smirnov test results indicate that all the independent variables (except HMO Penetration Rate) have a statistically significant test result.

Table 29. Kolmogorov-Smirnov Tests of Normality Invited Only Hospitals

	Statistic	df	p
HMO Penetration Rate	1.341	437	.055
Excess Capacity	1.398	454	.040
Number of Services Offered	2.216	415	.000
Operating Income/Admission	3.036	433	.000
Case Mix Index	2.158	459	.000
Number of HMO Contracts	4.412	341	.000
Herfindahl Index	4.889	444	.000
Community Orientation	7.436	383	.000
Size	2.680	454	.000

As a consequence of the findings in earlier tables, the Kruskal-Wallis test was performed on the Adopters versus Non-Adopters groups. Table 30 shows the results of the tests. Chi-square values are presented with accompanying significance levels. The degree of freedom equals one for all groups.

According to the non-parametric test, Excess Capacity, Number of Services Offered, Case Mix Index and Size have highly statistically significant Chi-square values ($p < 0.005$). Herfindahl Index's Chi-square measure is also statistically significant at a lower significance level ($p < 0.1$). The degree of freedom equals one for all groups. Herfindahl Index's Chi-square measure is also statistically significant.

Table 30. Kruskal-Wallis Test for Continuous Independent Variables by Adopter and Non-Adopter Hospitals – Invited Organizations Only

	Chi-Square	df	Significance
HMO Penetration Rate	.705	1	.401
Excess Capacity	22.396	1	.000
Number of Services Offered	10.778	1	.001
Operating Income/Admission	.693	1	.405
Case Mix Index	21.138	1	.000
Herfindahl Index	2.976	1	.085
Number of HMO Contracts	1.468	1	.226
Community Orientation	1.918	1	.166
Size	24.114	1	.000

Operating Income Per Admission, HMO Penetration Rate, Number of HMO Contracts and Community Orientation are found not to be significantly different between Adopters and Non-Adopters. The parametric and nonparametric tests had the same results for Adopters versus Non-Adopters.

Table 31 presents the findings of ANOVA F-statistics by Early Adopters versus Late Adopters. Values for F-statistics as well as the various levels of significance of the findings is shown. The result is presented for the continuous variables. The degree of freedom equals one for each group.

The results for ANOVA in this case are the same as they would be for t-statistics because there are two categories only, Early Adopter and Late Adopter. None of the independent variables show any statistically significant F-value on $p < 0.05$ level. Size is barely significant at $p < 0.1$ level. The null hypothesis of equal means across the Early and Late Adopter groups cannot be rejected. . None of the independent variables show any statistically significant F-value.

Table 31. ANOVA Results for Continuous Independent Variables by Early Adopter and Late Adopter Hospitals

	F Statistics	df	Significance
HMO Penetration Rate	2.319	1	.130
Excess Capacity	1.479	1	.225
Number of Services Offered	.519	1	.472
Operating Income/Admission	.031	1	.860
Case Mix Index	.073	1	.787
Herfindahl Index	1.232	1	.269
Number of HMO Contracts	1.464	1	.228
Community Orientation	.664	1	.416
Size	2.763	1	.098

The Kruskal-Wallis nonparametric test shows similar results of non-statistically significant differences between the two groups of hospitals for all the variables except for Number of HMO Contracts and Herfindahl Index. Chi-square values as well as levels of significance were studied. Number of HMO Contracts has a 3.043, and Herfindahl Index has a 2.939 Chi-square value and significant levels of 0.081 and 0.086 in the non-parametric procedure.

Descriptive Statistics and Univariate Analyses for the Self-Reporting Group of Hospitals

Table 32 shows the frequency distribution of Adopter versus Non-Adopter, Early and Late Adopter groups. Also the ordered categorical adoption stage variables within the group of 228 hospitals that self reported to Leapfrog without being invited to fill out the survey are presented. Count and percentage values are shown. Count and percent values can be compared across the Non-Adopter and Adopters as well as the Early and Late Adopter groups.

Table 32. Frequency Distribution of Dependent Variables within the Self-Reporting Group

	Count/Percent	Count/Percent	Count/Percent
Non-Adopters	148 (68)		
Adopters	69 (32)		
	217 (100)		
Early Adopter		36 (52)	
Late Adopter		33 (48)	
		69 (100)	
Fully Implemented			5 (2)
Good Progress			31 (14)
Good Early Stage			33 (15)
Willing To Report			148 (68)
			217 (100)

There are 69 Adopter hospitals (32 percent of the population) and 148 Non-Adopter hospitals (68 percent) in the sample of 217 hospitals. Thirty-six organizations, or 52 percent of the Adopters, are Early Adopters while 48 percent, or 33 hospitals, are Late Adopters. Five hospitals (2.3 percent of the study population) are in the category of Fully Implemented. Thirty-one hospitals (14 percent) are in the Good Progress category. Thirty-three hospitals (15 percent) belong to the Good Early Stage Effort category while 148 (68 percent) are in the Willing To Report But Did Not Meet Leapfrog Criteria class. (This study population does not include any organizations that did not respond to the Leapfrog survey because these are all self-reporting organizations; consequently, they are all self-selected to be respondents.)

Table 33 shows the results for the cross tabulation of the dichotomous variables by Adopters versus Non-Adopters. Neither Ownership nor System Membership or Salaried Physician variables have any statistically significant Chi-square measure at

Table 33. Cross tabulation Chi-Square Results for Categorical Independent Variables by Adopter Versus Non-Adopter Hospitals – Self-Reporting Group

	Pearson Chi-Square	df	Significance (2-Sided) for Chi-Square	Lambda for Row Variable	Approximate Significance For Lambda
Salaried Physician	0.506	1	0.477	0.000	0.000
Ownership	2.911	1	0.088	0.029	0.109
System Membership	1.722	1	0.189	0.000	0.000

level 0.05. Ownership has a Chi-square value that is significant at $p < 0.1$ level, but the Lambda directional measure is not statistically significant. Falling into Adopter or Non-Adopter categories is independent of being in any of the dichotomous categories of the three categorical variables for the self- reporting hospitals. Salaried physician variable has a 0.506 Pearson chi-square correlation statistics with 0.477 significance level. Variable ownership has a significance level of 0.088 but the Lambda value is 0.029.

Table 34 presents the cross tabulation results for Early and Late Adopter categories. Values for Pearson chi-square statistics and accompanying significance levels are shown. In addition to the Pearson statistics, Lambda for row variables are also presented with approximate significance values for Lambda. Values for Pearson chi-square statistics and accompanying significance levels are shown. In addition to the Pearson statistics, Lambda for row variables are also presented with approximate significance values for Lambda.

Table 34. Cross tabulation Chi-Square Results for Categorical Independent Variables by Early Adopter Versus Late Adopter Hospitals – Self-Reporting Group

	Pearson Chi-Square	df	Significance (2-Sided) for Chi-Square	Lambda for Row Variable	Approximate Significance For Lambda
Salaried Physician	0.155	1	0.694	0.000	0.000
Ownership	1.704	1	0.192	0.143	0.447
System Membership	2.148	1	0.143	0.000	0.000

Neither Salaried Physician nor System Membership or Ownership variables have statistically significant Chi-square measures at level 0.05 or 0.1. Falling into Early Adopter or Late Adopter categories is independent of being in any of the dichotomous categories of the three categorical variables.

Table 35 presents the findings of ANOVA F-statistics by Adopters versus Non-Adopters. The results for ANOVA in this case are the same as they would be for t-statistics because there are two categories only, Adopter or Non-Adopter. Case Mix Index and Size have large F-values and high significance levels, $p < 0.005$. Herfindahl Index is also statistically significantly different, although on a lower significance level, p less than 0.05. The results for ANOVA in this case are the same as they would be for t-statistics. Adopter or Non-Adopter. Case Mix Index and Size have large F-values and high significance levels. Degree of freedom is also presented in the table .Degree of freedom is one for each group.

Table 35. ANOVA Results for Continuous Independent Variables by Adopter and Non-Adopter Hospitals – Self-Reporting Group

	F Statistics	df	Significance
HMO Penetration Rate	.237	1	.627
Excess Capacity	.068	1	.795
Number of Services Offered	2.362	1	.126
Operating Income/Admission	1.655	1	.200
Case Mix Index	24.439	1	.000
Herfindahl Index	6.378	1	.013
Number of HMO Contracts	.040	1	.843
Community Orientation	2.474	1	.118
Size	24.466	1	.000

The variables--Community Orientation, Operating Income Per Admission, Number of HMO Contracts, HMO Penetration Rate and Excess Capacity--do not show statistically significant difference between the Adopter and Non-Adopter group means.

Table 36 shows the actual means for the Adopter and Non-Adopter groups for each continuous independent variable. As the result shows, Non-Adopters have a lower HMO market penetration rate and a somewhat higher excess capacity, offer fewer services, have lower case mix and Herfindahl indexes, and have a much lower bed size than Adopters. Although the difference is not statistically significant, the Non-Adopters have a much lower (about half) Operating Income per Admission. Non-adopter organizations have 20 dollar operating income per admission while adopter hospitals have 43 dollars. The bed size for adopters is 335 while for non-adopter organizations the same variable shows s180. Non-Adopters have a lower HMO market penetration rate and a somewhat higher excess capacity.

Table 36. Means of Independent Variables by Adopters And Non-Adopters – Self-Reporting Group

	Adopters	Non-Adopters
HMO Penetration Rate	24.15	23.00
Excess Capacity	38.24	38.93
Number of Services Offered	51.97	46.29
Operating Income/Admission	43.20	20.91
Case Mix Index	1.48	1.29
Number of HMO Contracts	7.53	7.74
Herfindahl Index	.69	.55
Community Orientation	5.19	4.80
Size	335	180

Table 37 presents the results for homogeneity of variance. Levene statistics are shown for the continuous variables: HMO penetration rate, excess capacity, number of services offered, operating income per admission, case mix index, Herfindahl index, community orientation, size and number of HMO contracts for the self-reporting group of hospitals. Beside the Levene statistics the accompanying levels of significance are presented as well. The degree of freedom equals with one and the number of valid cases in the group (for the specific variable) minus one. Size violates the equal variances assumption at 0.05 level. Excess Capacity violates the assumption at $p < 0.1$ level. .

Table 38 shows the findings for testing the normality of the independent variables. Kolmogorov-Smirnov statistics and accompanying levels of significance are presented. The degree of freedom equals with the number of cases minus one for each variable. The Kolmogorov-Smirnov test results indicate that all the independent variables except HMO Penetration Rate, Excess Capacity and Case Mix Index have a statistically significant test result at $p < 0.05$ level.

Table 37. Test of Homogeneity of Variances – Self-Reporting Group

	Levene Statistic	df1	df2	Significance
HMO Penetration Rate	.548	1	118	.461
Excess Capacity	3.731	1	192	.055
Number of Services Offered	1.250	1	176	.265
Operating Income/Admission	1.042	1	192	.309
Case Mix Index	2.099	1	192	.149
Herfindahl Index Hospital	1.767	1	118	.186
Community Orientation	.165	1	158	.685
Size	10.581	1	192	.001
Number of HMO Contracts	2.695	1	132	.103

Table 38. Kolmogorov-Smirnov Tests of Normality – Self-Reporting Group

	Statistic	df	p
HMO Penetration Rate	1.271	120	.079
Excess Capacity	.990	194	.281
Number of Services Offered	1.542	178	.017
Operating Income/Admission	2.339	194	.000
Case Mix Index	1.292	195	.071
Number of HMO Contracts	1.730	134	.005
Herfindahl Index	2.205	120	.000
Community Orientation	3.490	160	.000
Size	2.334	194	.000

As a consequence of the findings in the above tables, the Kruskal-Wallis test was performed on the Adopters versus Non-Adopters groups. Table 39 presents the results. Chi-square values and accompanying levels of significance are shown. The degree of freedom equals one for each variable.

Table 39. Kruskal-Wallis Test for Continuous Independent Variables by Adopter and Non-Adopter Hospitals – Self-Reporting Group

	Chi-Square	df	Significance
HMO Penetration Rate	.383	1	.536
Excess Capacity	.052	1	.819
Number of Services Offered	6.733	1	.009
Operating Income/Admission	2.516	1	.113
Case Mix Index	21.533	1	.000
Herfindahl Index	5.473	1	.019
Number of HMO Contracts	.349	1	.555
Community Orientation	5.426	1	.020
Size	26.148	1	.000

According to the non-parametric test, Case Mix Index and Size have highly statistically significant Chi-square values ($p < 0.005$). Number of Services Offered, Herfindahl Index and Community Orientation's Chi-square measure are also statistically significant at a lower significance level ($p < 0.05$). Operating Income per Admission, HMO Penetration Rate, Excess Capacity and Number of HMO Contracts are found not to be significantly different between Adopters and Non-Adopters.

Table 40 presents the findings of ANOVA F-statistics by Early Adopters versus Late Adopters. The results for ANOVA in this case are the same as they would be for t-statistics because there are two categories only, Early Adopter and Late Adopter. None of the independent variables show any statistically significant F-value on $p < 0.05$ level. Number of HMO Contracts is significant only at $p < 0.1$ level. The null hypothesis of equal means across the Early and Late Adopter groups cannot be rejected. . None of the independent variables show any statistically significant F-value on $p < 0.05$ level. Number of HMO Contracts is significant only at $p < 0.1$ level.

Table 40. ANOVA Results for Continuous Independent Variables by Early and Late Adopter Hospitals – Self-Reporting Group

	F Statistics	df	Significance
HMO Penetration Rate	.000	1	.992
Excess Capacity	.580	1	.449
Number of Services Offered	.026	1	.872
Operating Income/Admission	.612	1	.437
Case Mix Index	2.507	1	.118
Herfindahl Index	1.729	1	.194
Number of HMO Contracts	3.263	1	.077
Community Orientation	.095	1	.759
Size	2.245	1	.139

The Kruskal-Wallis non-parametric test shows similar results of non-statistically significant differences between the two groups of hospitals for all the variables except for Case Mix Index and Size. Size has a 4.547 Chi-square value and a significance level of 0.033 in the non-parametric procedure. Case Mix Index has a Chi-square value of 2.782 and statistical significance of 0.095.

Correlation Statistics For The Invited Respondents

Table 41 shows the correlation values for the invited group. Correlation statistics are important to study because they indicate how independent the independent variables are. How independently the study variables influence the state of the dependent variables. If the variables are too highly correlated then a false effect will show up in the results. In that case variables should be dropped from the model. The Highest Pearson correlation statistics is 0.548 for Size and Case Mix Index. The next highest value is 0.403 for Size and Number of Services Offered. None of the values is as high as 0.70. No variable should be dropped from the model as redundant of other variables.

Table 41. Correlation Statistics for the Invited Respondents

	a	b	c	d	e	f	g	h	i	j	k	l
a	1											
b	-.033	1										
c	.013	-.223**	1									
d	-.115*	.002	-.020	1								
e	-.066	-.307**	.28**	.010	1							
f	.097	-.068	.009	.101	-.002	1						
g	-.053	.115*	-.083	.147**	-.01	-.12*	1					
h	-.003	-.003	.25**	.208**	.060	.094	-.049	1				
i	-.039	-.081	.29**	-.045	.077	-.079	-.034	.030	1			
j	.178**	-.204**	.19**	-.072	-.03	-.065	-.045	.056	.053	1		
k	.125*	-.199**	.130*	-.17**	-.03	.049	.061	-.12*	.112*	.075	1	
l	-.054	-.346**	.41**	-.015	.55**	.070	-.034	.096*	.161**	.080	.129**	1

Double star values are significant at level 0.05; Single stars are significant at level 0.01
a: HMO Penetration Rate, b: Excess Capacity, c: Number of Services, d: Operating Income Per Admission, e: Case Mix Index, f:Number of HMO Contracts, g: Herfindahl Index, h: System Membership, i:Salaried Physicians, j:Community Orientation, k: Ownership, l: Size

Correlation Statistics for The Self-Reporting Group

Table 42 shows the correlation values for the self-reporting group. Double star values are significant at level 0.05 and single star values are significant at level 0.01 in

Table 42. Correlation Statistics for the Self-Reporting Group

	a	b	c	d	e	f	g	h	i	j	k	l
a	1											
b	-.118	1										
c	.164	-.262**	1									
d	-.179	-.048	-.006	1								
e	-.043	-.319**	.533**	.177*	1							
f	.242*	-.139	.050	.025	.006	1						
g	-.304**	.033	-.065	.163	.351**	-.147	1					
h	.081	-.115	.297**	.213**	.353**	.100	.044	1				
i	.099	-.095	.137	-.302**	-.048	-.010	-.053	-.155*	1			
j	.050	-.188*	.271**	.049	.319**	.071	.062	.287**	.019	1		
k	.240*	-.154	.25**	-.49**	-.02	-.071	-.060	-.314**	.34**	.131	1	
l	-.045	-.27*	.63**	.078	.7**	.086	.26**	.235**	.050	.28**	.067	1

the table. Notation "a" indicates HMO Penetration Rate, "b" indicates Excess Capacity, "c" indicates Number of Services, "d" indicates Operating Income Per Admission, "e" indicates Case Mix Index, "f" indicates Number of HMO Contracts, "g" indicates Herfindahl Index, "h" indicates System Membership, "i" indicates Salaried Physicians, "j" indicates Community Orientation, "k" indicates Ownership and "l" indicates Size

Size and Case Mix Index have a Pearson correlation coefficient of 0.715. Although this level of correlation is slightly higher than the customary cutoff point of 0.70, the two variables will be kept in the model because they are operationalizing different theory constructs. The next highest value is 0.630 for Size and Number of Services Offered, and it is less than 0.70, also kept in the model. Most of the other values are in the 0.20s or 0.30s ranges.

Multivariate Statistical Results for The Invited Respondents

Table 43 presents the findings for the logistic regression model for explaining Adopter and Non-Adopter status. The adopter group of hospitals is compared to the the non-adopter group of hospitals by analyzing only the invited group of organizations. Only those hospitals that returned a survey after Leapfrog's survey request are included in the sample. Excess Capacity and Case Mix Index have statistically significant Wald statistics (at $p < 0.05$ level).

Table 43. Logistic Regression for Adopters and Non-Adopters Invited Hospitals

	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. Exp(B) Lower	Upper
HMO Penetration Rate	.013	.011	1.451	.228	1.013	.992	1.03
Excess Capacity	-.024	.012	4.178	.041	.976	.954	.999
Number of Services	.008	.007	1.132	.287	1.008	.994	1.02
Op Income/Admission	.000	.001	.056	.814	1.000	.998	1.00
Case Mix Index	1.940	.733	7.006	.008	6.955	1.654	29.2
Number of HMO Cont	.009	.007	1.518	.218	1.009	.995	1.02
Herfindahl Index	-.534	.872	.375	.540	.586	.106	3.23
System Membership(1)	.316	.450	.492	.483	1.371	.568	3.31
Salaried Physicians(1)	-.321	.307	1.094	.296	.725	.397	1.32
Community Orientation	.082	.122	.450	.502	1.085	.855	1.37
Ownership(1)	-.446	.505	.780	.377	.640	.238	1.72
Size	.000	.001	.241	.623	1.000	.999	1.00

Table 44 presents the accompanying model fit for the logistic regression for the adopter and non-adopter hospitals in the group of invited organizations. The statistics for -2Log-likelihood and Hosmer-Lemeshow goodness of fit are presented. The accompanying levels of significance are also shown.

Table 44. Model and Goodness of Fit Statistics – Adopters and Non-Adopters for Invited Group

	Chi-square	df	Significance	-2LL
Model Fit	34.273	12	.001	318.547
Goodness of Fit	13.443	8	.097	

The model has a statistically significant Chi-square value for model fit. The Hosmer-Lemeshow statistic has a significance value larger than 0.05, which also indicates that the hypothesis of the model fitting the data cannot be rejected. The model predicts 66.8 percent of the classification of the dependent variable correctly. Dropping either the Size or the Number of Services Offered (because of high correlation between them and Case Mix Index) does not improve the model fit or classification prediction. Nor does it increase the number of statistically significant variables.

Table 45 presents the findings for the logistic regression model for explaining Early Adopter and Late Adopter status. The table shows the Wald statistics with the corresponding level of significanceand the upper and lower confidence intervals. The B-value and the Exponetial B-value are also shown for each independent variables. HMO Penetration Rate and Ownership have statistically significant Wald statistics (at $p < 0.1$ level).

Table 45. Logistic Regression for Early Adopters and Late Adopters for Invited Hospitals

	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. Exp(B) Lower	Upper
HMO Penetration Rate	.036	.020	3.344	.067	1.037	.997	1.077
Excess Capacity	.004	.023	.033	.857	1.004	.960	1.050
Number of Services	.000	.002	.011	.917	1.000	.996	1.003
Operating Income/Admission	.036	1.122	.001	.975	1.036	.115	9.344
Case Mix Index	.009	.011	.639	.424	1.009	.987	1.032
Number of HMO Contracts	2.071	1.931	1.150	.284	7.929	.180	349.11
Herfindahl Index	.435	.774	.316	.574	1.545	.339	7.038
System Membership(1)	-.086	.503	.029	.865	.918	.342	2.459
Salaried Physicians(1)	-.329	.255	1.664	.197	.720	.437	1.186
Community Orientation	-2.016	1.126	3.207	.073	.133	.015	1.210
Table 45 Continued							
Ownership(1)	.001	.013	.005	.944	1.001	.976	1.026
Size	.001	.001	1.638	.201	1.001	.999	1.004
Constant	.010	2.499	.000	.997	1.010		

Table 46 presents the accompanying model fit, -2Log-likelihood and Hosmer-Lemeshow goodness of fit statistics. The model does not have a statistically significant Chi-square value for model fit. The Hosmer-Lemeshow statistic has a significance value larger than 0.05, the hypothesis of the model fitting the data should not be rejected.

Table 46. Model and Goodness of Fit Statistics – Early Adopters and Late Adopters for Invited Group

	Chi-square	df	Significance	-2LL
Model Fit	14.934	12	.245	121.337
Goodness of Fit	4.374	8	.822	

However, the value of model fit is not significant. The model predicts 68.6 percent of the classification of the dependent variable correctly. Dropping either the Size or the Number of Services Offered (because of a high correlation between them and Case Mix Index) does not improve the model fit or classification prediction. Nor does it increase the number of statistically significant variables.

Table 47 presents the findings of the likelihood ratio test for explaining the four Adoption Stages of the Leapfrog CPOE initiative. Chi-square values for the individual independent variables are presented. In addition to the chi-square statistics, the accompanying levels of significance are shown as well.

Operating Income per Admission and Case Mix Index have statistically significant Chi-square statistics (at level $p < 0.05$) for the –2Log likelihood of the reduced model. Excess Capacity and Number of Services are close to being statistically significant at $p < 0.1$ level (0.112 and 0.105). The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0. Omitting variables Excess Capacity, Operating Income per Admission and Case Mix Index has an effect on the model.

Table 47. Likelihood Ratio Test for Adoption Stages for Invited Hospitals

	-2LL of Reduced Model	Chi-square	Df	p
Intercept	488.543	14.433	3	.002
HMO Penetration Rate	478.145	4.034	3	.258
Excess Capacity	480.095	5.984	3	.112
Number of Services	480.258	6.147	3	.105
Operating Income/Admission	482.473	8.362	3	.039
Case Mix Index	484.493	10.382	3	.016
Number of HMO Contracts	477.712	3.602	3	.308
Herfindahl Index	475.313	1.202	3	.752
System Membership	476.479	2.368	3	.500
Salaried Physicians	475.983	1.872	3	.599
Community Orientation	475.620	1.509	3	.680
Ownership	477.579	3.468	3	.325
Size	477.657	3.546	3	.315

Table 48 presents the accompanying model fit. Statistics for -2Log-likelihood and goodness of fit are shown. The results show the chi-square values and the accompanying levels of significance for model and goodness of fit statistics.

Table 48. Model and Goodness of Fit Statistics – Adoption Stage for Invited Group

	Chi-square	df	Significance	-2LL
Model Fit	78.355	36	.000	575.986
Goodness of Fit	657.077	747	.992	

The model has a statistically significant Chi-square value for model fit. The goodness of fit statistic has a significance value larger than 0.05, which also indicates that the hypothesis of the model fitting the data cannot be rejected. The correct classification percentage is 63. Dropping either the Size or the Number of Services Offered (because of high correlation between them and Case Mix Index) does not improve the model fit or classification prediction. Dropping any of the two variables does not increase the number of statistically significant variables, either.

Table 49 presents the findings of running a multiple linear regression analysis for the data using the Adoption Stage variable as a continuous dependent variable. Presenting the adoption stage variable as a continuous dependent variable instead of the ordinal categorical form of the dependent variable as was done earlier creates the possibility of a potentially easier interpretation of the effect of independent variables. Statistics for standardized beta and t-values are shown for each independent variable. In addition, the results of the accompanying levels of significance are shown. Case Mix Index, Herfindahl Index and Salaried Physician variables have statistically significant (at level 0.1) t-values.

Table 49. Multiple Linear Regression Statistics for Adoption Stage – Invited Group

	Standardized Beta	t-value	p
Constant		1.751	.081
HMO Penetration Rate	-.014	-.251	.802
Excess Capacity	-.092	-1.474	.141
Number of Services	.042	.640	.523
Operating Income/Admission	-.042	-.727	.468
Case Mix Index	.122	1.790	.074
Number of HMO Contracts	.077	1.349	.178
Herfindahl Index	-.115	-2.017	.045
System Membership	-.034	-.570	.569
Salaried Physician	.105	1.814	.071
Community Orientation	.005	.082	.935
Ownership	.040	.679	.498
Size	.071	1.007	.315

R=0.334, R square=0.112

Dropping either the Size or the Number of Services Offered (because of high correlation between them and Case Mix Index) does not improve the model fit or classification prediction. Nor does it increase the number of statistically significant variables.

Multivariate Statistics for The Self-Reporting Group

Table 50 presents the findings for the logistic regression model for explaining Adopter and Non-Adopter status. B and Wald statistics are shown. The accompanying levels of significance are also presented. For additional results the lower and upper boundaries for the 95 percent confidence intervals are also shown. Both the continuous and categorical variables are studied.

Table 50. Logistic Regression for Adopters and Non-Adopters – Self-Reporting Hospitals

	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. Exp(B)	
						Lower	Upper
HMO Penetration Rate	.034	.027	1.603	.205	1.034	.982	1.090
Excess Capacity	.006	.024	.058	.810	1.006	.960	1.054
Number of Services	-.018	.017	1.216	.270	.982	.951	1.014
Operating Income/Admission	.000	.003	.000	1.000	1.000	.994	1.006
Case Mix Index	2.698	1.77	2.318	.128	14.849	.461	478.5
Number of HMO Contracts	-.106	.061	3.002	.083	.900	.798	1.014
Herfindahl Index	-.349	1.04	.113	.737	.705	.091	5.434
System Membership(1)	.739	1.69	.190	.663	2.094	.076	57.89
Salaried Physicians(1)	-1.218	.681	3.196	.074	.296	.078	1.124
Community Orientation	.268	.247	1.179	.278	1.308	.806	2.122
Ownership(1)	.992	.848	1.369	.242	2.698	.512	14.22
Size	.001	.002	.122	.726	1.001	.997	1.004
Constant	-4.540	3.08	2.165	.141	.011		

Number of HMO Contracts has a statistical significance of 0.083. The Salaried Physician variables show statistically significant Wald measures with a p value of 0.074. Both variables are statistically significant on level 0.1.

Table 51 presents the accompanying model fit. Model fit as well as Hosmer-Lemeshow goodness of fit statistics are shown. Chi-square values and –2Log-Likelihood statistics are presented with accompanying levels of significance.

Table 51. Model and Goodness of Fit Statistics – Adopters and Non-Adopters for Self-Reporting Group

	Chi-square	df	Significance	-2LL
Model Fit	14.125	12	.293	84.747
Goodness of Fit	5.953	8	.652	

The model has no statistically significant Chi-square value for model fit. The Hosmer-Lemeshow statistic has a significance value larger than 0.05, which indicates that the hypothesis of the model fitting the data cannot be rejected. However, all other statistics indicate inadequate fit, including the p value of 0.293 for final model fit. The model has a 73 percent correct classification prediction. Dropping the Size variable improves the statistical significance of the Number of HMO Contracts and Salaried Physician variables on level $p < 0.1$ and provides a statistically significant Case Mix Index variable on level $p < 0.05$ ($p = 0.049$, Wald = 3.88, Exp(B) = 20.355 and correct classification of 70 percent). That model still did not have a statistically significant Chi-square value for model fit or Goodness of Fit statistics. Dropping the Number of Services Offered does not provide any significant benefit in model fit.

Table 52 presents the findings for the logistic regression model for explaining Early Adopter and Late Adopter status. Findings for the self-reporting group are presented. B and Wald statistics and accompanying levels of significance are shown.

Table 52. Logistic Regression for Early Adopters and Late Adopters for Self-Reporting Hospitals

	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. Exp(B) Lower	Upper
HMO Penetration Rate	-.015	.081	.036	.850	.985	.840	1.15
Excess Capacity	.100	.069	2.110	.146	1.105	.966	1.26
Number of Services	-.038	.048	.628	.428	.962	.876	1.05
Op Income/Admission	.014	.012	1.260	.262	1.014	.990	1.03
Case Mix Index	7.499	4.23	3.131	.077	1805.72	.446	7318
Number of HMO Cont	.062	.164	.145	.703	1.064	.772	1.46
Herfindahl Index	-.407	3.07	.017	.895	.666	.002	277.
System Membership(1)	18.195	4019	.000	1.000	7982473	.000	.
Salaried Physicians(1)	2.378	1.36	3.021	.082	10.784	.738	157
Community Orientation	.308	.659	.219	.640	1.361	.374	4.95
Ownership(1)	-3.469	2.14	2.626	.105	.031	.000	2.06
Size	-.001	.005	.062	.803	.999	.989	1.00
Constant	-13.83	10.6	1.669	.196	.000		

The Case Mix Index has a Wald statistics of 3.131. The variable Salaried Physicians has a Wald statistics of 3.021. The variable Ownership has a Wald statistics of 2.626. All three variables have statistically significant Wald statistics (at $p < 0.1$ level).

Table 53 presents the accompanying model fit, -2Log-likelihood and Hosmer-Lemeshow goodness of fit statistics. Although 87 percent of the dependent variables are

Table 53. Model and Goodness of Fit Statistics – Early Adopters and Late Adopters for Self-Reporting Group

	Chi-square	df	Significance	-2LL
Model Fit	15.526	12	.214	24.855
Goodness of Fit	14.645	8	.066	

categorized correctly using the model, the final model does not have a statistically significant Chi-square value for model fit. The hypothesis of the model fitting the data should be rejected. Dropping Total Services Offered because of the high correlation coefficient with Case Mix Index and Size variables increases the number of statistically significant variables of the model.

Table 54 presents the findings for the likelihood ratio test for explaining the four Adoption Stages of the Leapfrog CPOE initiative. No statistically significant findings.

Table 54. Likelihood Ratio Test for Adoption Stages for Self-Reporting Hospitals

	-2LL of Reduced Model	Chi-square	Df	p
Intercept	110.924	3.419	3	.331
HMO Penetration Rate	108.847	1.341	3	.719
Excess Capacity	109.581	2.075	3	.557
Number of Services	110.364	2.859	3	.414
Operating Income/Admission	109.084	1.579	3	.664
Case Mix Index	112.173	4.667	3	.198
Number of HMO Contracts	111.300	3.795	3	.285
Herfindahl Index	108.283	.778	3	.855
System Membership(1)	108.223	.717	3	.869
Salaried Physicians(1)	112.023	4.518	3	.211
Community Orientation	109.261	1.756	3	.625
Ownership(1)	110.241	2.735	3	.434
Size	107.857	.352	3	.950

Table 55 presents the accompanying model fit and Hosmer-Lemeshow statistics for the self-reporting group of organizations. The -2Log-likelihood and goodness of fit statistics are shown and the associated levels of significance. Chi-square values and – 2Log Likelihood statistics are presented for both model fit and goodness of fit. The model fit has a 44.305 value for chi-square statistics. The accompanying level of significance is 0.161. The goodness of fit has a chi-square value of 138.905 and a statistical significance of 0.99.

The model has no statistically significant Chi-square value for model fit. Correct classification prediction is 70 percent. The goodness of fit statistic has a significance value larger than 0.05, which indicates that the hypothesis of the model fitting the data cannot be rejected. However, all other statistics indicate the opposite. The model does not fit the data. Dropping variable Size makes the Case Mix Index significant.

Table 55. Model and Goodness of Fit Statistics – Adoption Stage for Self-Reporting Group

	Chi-square	df	Significance	-2LL
Model Fit	44.305	36	.161	107.506
Goodness of Fit	138.905	180	.990	

Table 56 presents the findings of running a multiple linear regression analysis for the data. This model is using the Adoption Stage variable as continuous dependent variable. This approach creates a potentially easier interpretation of the effect.

Table 56. Multiple Linear Regression Statistics for Adoption Stage – Self-Reporting Group

	Standardized Beta	t-value	p
Constant		.286	.775
HMO Penetration Rate	.143	1.292	.200
Excess Capacity	.067	.618	.538
Number of Services	-.207	-1.389	.169
Operating Income/Admission	-.044	-.375	.709
Table 56 Continued			
Case Mix Index	.279	1.749	.084
Number of HMO Contracts	-.008	-.078	.938
Herfindahl Index	.022	.187	.852
System Membership	-.102	-.841	.403
Salaried Physician	.109	1.022	.310
Community Orientation	.027	.253	.801
Ownership	-.146	-1.067	.289
Size	.344	2.152	.034

R=0.47, R square=0.221

Case Mix Index and Size have statistically significant t-values either at 0.1 (Case Mix Index) or 0.05 (Size) level. The model fits the data. Dropping Total Services Offered or Size (because of the high level of collinearity between each other and Case Mix Index) does not increase the number variables with a statistically significant t-value.

Summary

This chapter presented the results of the descriptive statistics, univariate analyses and multivariate analyses. First, the descriptive statistics and univariate results of the combined population of hospitals were shown. The combined population included invited survey returning hospitals, invited but not responding hospitals (categorized as Non-Adopter) and self-reporting hospitals.

The not responding hospitals showed statistically significant differences in multiple independent variables compared to the invited responding hospitals. Number of

Services Offered, Case Mix Index, Size, Salaried Physician and Ownership variables were all statistically significantly different between the invited responding and invited non-responding hospitals. As a consequence of this finding, the non-responding hospitals were removed from the study population and not included as Non-Adopters in the further analysis.

The univariate analyses of the combined population also found that the self-reporting group was different from the invited responding group in multiple independent variables. HMO Penetration Rate, Excess Capacity, Case Mix Index, Herfindahl Index, Community Orientation, Number of HMO Contracts, Salaried Physicians and Ownership were all statistically significantly different across the invited responding and self-reporting groups. As a consequence of this finding, the self-reporting group was separately analyzed for the univariate and multivariate methods.

The last section of the chapter presented the findings for the multivariate methods. Specifically, the bivariate logistic regression analyses for Adopter versus Non-Adopter, Early Adopter versus Late Adopter and Multinomial analyses for Adoption Stage were shown. Multiple Linear Regression methods were also run for Adoption Stage dependent variable.

Chapter 6 will present the interpretation and discussion of the findings. Results of hypothesis testing will be examined. Implications of the findings and limitations of the study will be discussed. Finally, areas for future research will be proposed.

Chapter 6: DISCUSSION

The purpose of this chapter is to provide interpretation of the findings presented in the previous chapter. First, the results of the individual hypothesis testing are provided. The expected and the actual signs of the coefficients for the various hypotheses as well as the presence or absence of statistically significant findings are discussed.

Next, the implications of the results are considered. Theoretical, policy and managerial implications are reviewed. Finally, limitations of the study are discussed. Limitations originating in data source and statistical methods are presented. Based on the study findings and limitations, recommendations for future research are provided.

Results of Hypotheses Testing

A summary of findings for the tested hypotheses is presented in Table 57. The tested hypotheses, expected sign of the coefficients, actual sign of the coefficients and level of statistical significance is shown for the three multivariate analyses for both the invited and self-selected respondents.

H1a: Hospitals in areas with greater HMO penetration will be more likely to adopt CPOE.

HMO penetration rate was found to be a significant determinant for CPOE adoption (p less than 0.1). HMO penetration rate had an expected positive sign for the model

Table 57. Results of Hypotheses Testing

H	Variables	Expected Sign	Adopter vs Non-Adopter		Early vs Late		Ordered	
			Inv	Self	Inv	Self	Inv	Self
H1a	HMO Penetr Rate	+	+	+	+*	-	+	+
H1b	N of HMO Cont	+	+	-*	+	+	-	+
H2	Herfindahl Index	+	+	+	-	+	+	-
H3	Excess Capacity	+	-**	+	+	+	-*	-
H4	Ownership	+	+	-	-	+*	-	+
H5	Comm Orientation	+	+	+	-*	+	+	+
H6	Salaried Physician	+	-	+*	+	-*	+	-
H7	Size	+	0	+	+	+	+	+
H8	Sys Membership	+	-	-	+	-	-	+
H9a	Num of Services	+	+	-	+	-	-	+
H9b	Case Mix Index	+	+**	+	+	+*	+**	+
H10	Op Inc Per Adm	+	0	+	+	+	-**	-

Inv: Invited Respondent, Self: Self-Reporting, *P < 0.10, **p < 0.05

coefficient. Five of the six models produced a positive coefficient. Both for the invited and self-reporting hospitals, an increased HMO penetration rate was found to be associated with a higher likelihood of CPOE adoption on a statistically non-significant level in the bivariate model. Similarly, the multinomial logistic model for both groups of hospitals found an increased likelihood of CPOE adoption when HMO penetration rate increased. In the case of self-reporting hospitals, a statistically non-significant late adoption was found. However, the invited group of respondents had a statistically significant increase in likelihood of early adoption in the case of higher HMO penetration rate in the specific hospital market (p < 0.1 level). The hypothesis about the number of HMO contracts a hospital has was presented next.

H1b: Hospitals with more HMO contracts are more likely to adopt CPOE.

The number of HMO contracts a hospital had was found to be a significant determinant of CPOE adoption status ($p < 0.1$). The variable Number of HMO Contracts had an expected positive sign for the model coefficient. Four of the models produced positive non-significant coefficients and two showed negative coefficients, one of them statistically significant. The bivariate model testing early adoption status had positive coefficients for both study populations. The multivariate model had the expected positive coefficient for the self-reporting group and a negative coefficient (decreased CPOE adoption likelihood) for the invited respondent group. The bivariate model testing the adoption status showed increased likelihood for the group of invited organizations. These were statistically non-significant findings. However, the group of self-reporting hospitals produced a statistically significant decreased likelihood of CPOE adoption in cases of increased number of HMO contracts ($p < 0.1$ level).

H2: Hospitals located in more competitive markets will be more likely to adopt CPOE.

Hospital market competition was not found to be a significant determinant of CPOE adoption or stage of adoption. The Herfindahl Index operationalized hospital market share. The Herfindahl Index is calculated by summing the squared proportions of hospital inpatient day market share. The smaller the index, the higher the competition. Hospital competition had an expected positive sign for the model coefficient. Four of the models produced positive coefficients. Increased competition was associated with a higher likelihood of CPOE adoption for both study populations for the bivariate adoption model. The invited group of hospitals also had a positive coefficient in the multinomial model. Increased competition was associated with decreased likelihood of early adoption for the invited organization but increased likelihood of early adoption for the self-reporting group. None of the findings were statistically significant on either 0.05 or 0.1 levels.

H3: Hospitals with excess capacity are more likely to adopt CPOE.

Excess capacity (unoccupied hospital beds on an average day) was found to be a statistically significant determinant of CPOE adoption ($p < 0.05$). Excess capacity had an expected positive sign for the model coefficient. Three of the models had positive coefficients while three of them had negative ones. Two of the negative coefficients had statistically significant p values. Increased level of excess capacity had an increased likelihood of CPOE adoption for the self-reporting group in the bivariate model. Higher excess capacity was also associated with increased likelihood of early adoption for both study populations. None of these findings was statistically significant. In the case of invited respondent hospitals, the bivariate model produced a negative coefficient for CPOE adoption. That is, an increase of excess capacity reduced the likelihood of CPOE adoption for invited respondents both in the bivariate and the multinomial models. These findings were statistically significant at $p < 0.05$ (bivariate) and $p < 0.1$ (multinomial) level. The multinomial model also showed a decreased likelihood of CPOE adoption for the self-reporting group with a negative model coefficient.

H4: Hospital ownership will have a significant effect on actual CPOE implementation rate, and not-for-profit hospitals are more likely to be actual implementers of CPOE than investor-owned hospitals.

Ownership status was found to be a significant determinant for early CPOE adoption ($p < 0.1$). Not-for-profit status had an expected positive sign for the model coefficient. Three of the models produced positive coefficients and three showed negative coefficients for not-for-profit status (the not-for-profit ownership status was the reference category for the tables in Chapter 5). In the case of the self-reporting group, not-for-profit status was associated with a reduced likelihood of CPOE adoption in the bivariate model. The invited respondents showed an increased likelihood of CPOE adoption but a decreased likelihood of early adoption in the bivariate models and a decreased likelihood of CPOE adoption in the multinomial model. None of these findings was statistically significant. However, the bivariate model on the self-reporting group produced a statistically significant (at level $p < 0.1$) increased likelihood of early CPOE adoption when ownership status was not-for-profit.

H5: Hospitals with higher community orientation are more likely to adopt CPOE than hospitals with weaker community orientation.

Community orientation was found to be a significant determinant for early CPOE adoption ($p < 0.1$). Community orientation had an expected positive sign for the model coefficient. Five of the six models produced positive coefficients, none of them statistically significant. The bivariate model testing early adoption on the group of invited respondents showed a negative statistically significant coefficient. That is, stronger community orientation was associated with a statistically significant decrease ($p < 0.1$) of the likelihood of early CPOE adoption in the case of invited respondents.

H6: Hospitals with in-house salaried physician staff are more likely to adopt CPOE than hospitals without a salaried physician staff.

Salaried physician staff was found to be a significant determinant for CPOE adoption and early CPOE adoption ($p < 0.1$). Salaried physician staff had an expected positive sign for the model coefficient (salaried physician on staff was the reference category in the tables of Chapter 5). Three of the models produced positive coefficients while three of them showed negative coefficients. The bivariate model for adoption produced a non-significant negative coefficient for the invited respondent group, but the model for the self-reporting group had a statistically significant positive coefficient ($p < 0.1$). That is, a higher likelihood of CPOE adoption was associated with physicians employed by the hospital than in other physician staffing situations. The multinomial model produced a non-significant positive coefficient for the invited respondent group and a non-significant negative coefficient for the self-reporting group. The bivariate model for testing early adoption showed a non-significant positive association for the invited respondent hospitals. However, the self-reporting group produced a statistically significant negative association for early adoption ($p < 0.1$). That is, the likelihood of early adoption decreased when physicians were employed by the hospital in the case of the self-reporting organizations.

H7: Hospitals with larger bed size are more likely to adopt CPOE than hospitals with smaller bed size.

Size was not found to be a significant determinant of hospitals' CPOE adoption or early adoption. Size had an expected positive sign for the model coefficient. Five of the six models produced positive coefficients, although none of them was statistically significant. The bivariate model for testing adoption had a zero coefficient in the case of invited respondents.

H8: Integrated delivery network or system member hospitals are more likely to adopt CPOE than non-member hospitals.

System or network membership was not found to be a significant determinant of CPOE adoption or early adoption. System membership had an expected positive sign for the model coefficient. Four of the six models produced a negative model coefficient. The bivariate model testing early adoption in the invited respondent group showed a positive coefficient. Also, the multinomial model for the self-reporting group had a positive coefficient. All other models showed a decreased likelihood of CPOE adoption or early adoption, although at a statistically non-significant level.

H9a: Hospitals offering more services are more likely to adopt the Leapfrog Group's CPOE initiative.

Number of services was not found to be a significant determinant of CPOE adoption or early adoption. Number of services had an expected positive sign for the model coefficient. Three of the six models produced positive model coefficients while the rest of them produced negative ones. None of the models showed statistically significant coefficients. Both the adoption and early adoption bivariate models produced positive coefficients in the case of the invited respondent group. Also, the multinomial model for the self-reporting group had a positive coefficient when tested for number of services offered by the hospital. The rest of the models had negative coefficients.

H9b: Hospitals with higher case mix indexes are more likely to adopt the Leapfrog Group's CPOE initiative.

Case mix index was found to be a significant predictor of CPOE adoption and early adoption ($p < 0.05$ and $p < 0.1$). It had an expected positive sign for the model coefficient. All six models produced positive coefficients. The bivariate model for adoption testing and the multinomial model in the case of the self-reporting group had non-significant positive coefficients. Similarly, the group of invited respondents in the early adoption bivariate model had a non-significant positive coefficient. The bivariate and multinomial models testing CPOE adoption had a statistically significant positive association in the case of invited respondent organizations. That is, in the case of the invited group, an increased case mix index was associated with an increased likelihood of CPOE adoption ($p < 0.05$). The self-reporting group produced a statistically significant positive coefficient in the early adoption bivariate model ($p < 0.1$). That is, in the case of the self-reporting hospitals, the increase of the case mix index was associated with an increased likelihood of early adoption.

H10: Hospitals with higher profit margins will be more likely to adopt the Leapfrog Group's CPOE initiative.

Operating Income per Admission was found to be a significant determinant of CPOE adoption ($p < 0.05$). Operating Income per Admission had an expected positive sign for the model coefficient. In the case of invited respondents, the bivariate model for adoption testing had zero for coefficient. The self-reporting group of the same model had a non-significant positive coefficient, same as both study populations for the bivariate early adoption model. In the case of self-reporting organizations, the multinomial model produced a non-significant negative coefficient. However, the invited respondent group showed a statistically significant negative coefficient. That is, in the case of invited respondent hospitals, the increased Operating Income per Admission was associated with a decreased likelihood of CPOE adoption (p < 0.0.5).

Summary of Hypotheses

Table 58 presents the summary of hypotheses testing. Study constructs and hypotheses are shown. Also the tested independent variables and statistically significant support (if found) for adoption or early adoption are noted.

Table 58. Support of Hypotheses and Study Constructs

Construct	Hypothesis	Variable	Support Adoption	Support Early Adoption
Operational Characteristics	H3	Excess Capacity	-	0
	H4	Ownership	0	+
	H6	Salaried Physician	+	-
	H9a	Number of Services Offered	0	0
	H9b	Case Mix Index	+	+
Organizational Characteristics	H5	Community Orientation	0	-
	H7	Size	0	0
	H8	System Membership	0	0
Financial Characteristics	H10	Operating Income Per Admission	-	0
Environmental Characteristics	H1a	HMO Penetration Rate	0	+
	H1b	Number of HMO Contracts	-	0
	H2	Herfindahl Index	0	0

+: Statistically significant result with expected sign found; -: Statistically significant result with opposite of expected sign found; **0**: No statistically significant finding

As Table 58 shows, two hypotheses were supported by the adoption models and three by the early adoption models. Three hypotheses had opposite findings from those expected with the adoption models and two by the early adoption models. Four hypotheses had no statistically significant findings either with the adoption or the early adoption models.

If construct support is analyzed, then the operational characteristics had four supporting and two opposing findings. Organizational characteristics had one opposing and no supporting findings. Similarly, financial characteristics had one opposing and zero supporting findings. However, while financial characteristics were operationalized by only one variable, organizational characteristics were operationalized and tested by three variables. Environmental characteristics were supported by one and opposed by one model. The statistically significant findings were the least strong for organizational characteristics with one finding and the strongest for operational characteristics with six findings.

In summary, support was found for several hypotheses. For the hypotheses representing operational characteristics, hypothesis 3 (excess capacity), hypothesis 4 (ownership), hypothesis 6 (salaried physician staff) and hypothesis 9b (case mix index) were found to be statistically significant. For the hypotheses representing organizational characteristics, hypothesis 5 (community orientation) was statistically significant. Operating Income Per Admission in hypothesis 10 was found significant for financial characteristics, and hypothesis 1a (HMO penetration rate) and hypothesis 1b (number of HMO contracts) were statistically significant for environmental characteristics.

Implications

As described in detail in Chapter 2, the Business Roundtable Member organizations that launched the Leapfrog Group declared the present level of inpatient medication errors unacceptable. Leapfrog incorporated the CPOE initiative as a management innovation in the original Leapfrog measures to increase patient safety. The literature does not provide unambiguous support for the CPOE initiative.

The study focused on the hospitals' response to the CPOE initiative because this is the only Leapfrog measure where the individual organizations have significant control over the implementation of the measure. Neither the implementation of the ICU Physician Staffing initiative (shortage of licensed ICU physicians), nor the compliance with the Evidence Based Hospital Referral initiative (finite pool of potential patients for the specific procedures) is within the full reach of individual management. The CPOE initiative also "fits" well the pattern of earlier health care management innovations that have ample literature.

However, Chapter 2 clearly shows that because of the ambiguity in the present literature about the effectiveness of the CPOE measure, hospital management will decide about compliance based on experience with previous management innovations and local environmental and organizational circumstances. These "characteristics" of the CPOE initiative that made it an excellent study subject also foreshadowed a potential problem for Leapfrog. Hospital management could decide that this time they will not "jump on the innovation bandwagon" but instead take a "wait and see approach" with CPOE compliance. A wait and see approach also would reduce variability within the population's response to the Leapfrog initiative and limit the study findings.

Policy and Managerial Implications

The findings show a limited success for Leapfrog's efforts. The relatively low level of statistical significance and the low number of statistically significant findings indicate that Leapfrog's influence is still limited. It also is possible that the lack of a clear logical pattern for adoption is a consequence of the constellation of two events: on one side, the ambiguous support for the CPOE initiative in the literature; and on the other, the management's experience with earlier "world changing" management innovations (that failed to deliver according to expectations). It also might raise doubts about the effectiveness of CPOE since the earlier innovations were touted in many cases by the same business consultants who are now promoting CPOE (Leapfrog has the policy to actively involve business consultants in the spread of safety measures).

From a policy point of view, it is important that the models support the hypothesis that not-for-profit organizations are more likely to be early adopters. Interestingly, this finding also coincides with the result that higher Operating Income Per Admission is associated with a lower likelihood of being a CPOE adopter. For profit hospitals are less likely to be "eager" to adopt, and organizations that could "afford" to adopt are less likely to do so.

This suggests the policy implication that hospitals might need financial incentives beyond those that are currently offered, potentially on a federal level, to "speed up" CPOE implementation in the hospital industry. In addition, it makes clear that allowing hospitals to convert to a for-profit status from a not-for-profit status has other implications beyond tax collection.

It is an important finding for policy makers, too, that--contrary to the theory-based hypothesis—a higher number of HMO contracts was associated with a lower likelihood of CPOE adoption. Hospitals with more numerous HMO contracts might feel more secure and less needy of adopting CPOE to comply with the Leapfrog requirement. The sense of security (of having more than one "supplier of patients") might be a stronger conflicting force than the amplified message of a CPOE compliance recommendation coming from multiple sources.

On the other hand, the hypothesis that an increased HMO market penetration rate increases the likelihood of early CPOE adoption was supported. Based on this finding, policy makers might want to focus their legislation/financing efforts on market areas where the HMO market share is lower than the national average.

Healthcare managers should learn from the study that hospitals having complicated cases would be most likely to need to implement Leapfrog's or other CPOE initiatives partly because other hospitals with complex cases are implementing it (and those that do not might have a competitive--or at least marketing—disadvantage) and partly because CPOE makes the most sense for organizations with complex cases (and consequently complex medication orders).

Managers also can learn that hospitals with employed physicians on staff, though less likely to become early adopters, will be more likely to decide to adopt CPOE eventually for the long term. Hospitals with physicians on staff might not jump on the bandwagon in the early stages of a healthcare IT initiative. These organizations might feel comfortable enough in the early stages, from the point of view of patient care continuity – and subsequent patient safety – by having permanent physician staff on site. However, when they decide to implement they can go through the process more easily by having more control over their physicians, as hypothesis 6 states.

For Leapfrog, the most important finding is the relative lack of urgency for hospitals to comply with the CPOE initiative. At the time of original reporting, hospitals seem to be withholding judgment about CPOE until more evidence is available. The relatively low significance of findings might also indicate that hospitals do not feel pressured enough to comply.

Leapfrog needs to refine its approach by including direct financial incentives for hospital participation. A refined approach also might entail assisting participating hospitals in the planning and decision making process, in selecting vendors, and in providing some form of standardization for acceptable CPOE systems. A new approach might even include pressuring CPOE vendors to reduce prices, or if nothing else, to provide an umbrella organization to increase hospitals' bargaining power. The Leapfrog organizations could provide financial assistance in the implementation phase. Of course, some of the suggested approaches might conflict with the interest of some Leapfrog member organizations (most notably IT and CPOE vendors).

It is good news for Leapfrog that numerous hospitals are deciding to self-report their CPOE compliance. However, the relatively low significance of findings, as well as the meager findings in the self-reporting group, indicate that some of these hospitals are interested mostly in showing off and not in actual compliance. This also suggests that hospital management is on a wait and see approach and not fully convinced about the usefulness of CPOE even in the self-reporting group. The fact that there is not much difference in the significance of findings between the invited and the self-reporting groups also suggests that Leapfrog needs a new approach for increasing hospital compliance.

Theory Implications

From a theoretical point of view, only limited support was found for the use of resource dependence theory using the current data and statistical methods. The statistical significance was not particularly strong for most of the findings, being significant at $p < 0.1$ level. Only excess capacity, case mix index and Operating Income per Admission were significant at $p < 0.05$ level. On the other hand, the relatively weak support for resource dependence theory does not mean that the theory cannot be used in further studies applied to CPOE implementations or to more general IT implementations in the health care sector.

H1a and H1b: The paper found partial support for the notion that higher HMO penetration increases the quality of hospital care (Sari, 2002) and the technical efficiency Brown, 2003) in area hospitals. The support was limited to HMO penetration rate. The study did not find support for the number of HMO contracts having a positive effect on CPOE adoption.

H2: The findings did not provide support for the assumption that more competitive hospital markets would increase the CPOE adoption rate (Pfeffer 2003).

H3: The paper also did not support the assumption of the resource dependence theory that hospitals with excess capacity are more likely to adopt CPOE (Pfeffer and Salancik, 2003).

H4: The study findings are consistent with the literature that not-for-profit hospitals behave differently from for-profit organizations (Walker and Humpreys, 1993). There is partial support that not-for-profit hospitals are more likely to adopt CPOE.

H5: The paper's findings did not align with the literature for community orientation and management innovation adoption (Ginn and Moseley, 2004). That is, there was no support for higher innovation adoption in hospitals with higher community orientation.

H6: The study results support the literature that the presence of house staff is an important factor in CPOE adoption (Morrisey, 2003 and Poon, et al., 2003).

H7: There was no positive or negative finding for the association of size and CPOE adoption mentioned in the literature (Glandon and Counte, 1995 and Burke, et al., 2002).

H8: Similarly, there were no statistically significant findings for system or delivery network membership being positively associated with CPOE adoption, as mentioned in the literature (Morrisey, 1996 and Burke, et al., 2002).

H9a and H9b: The study provides support for the literature regarding the association of service complexity and innovation adoption (Wang et al., 2005). However, the number of services offered was not found to be significant.

H10: The findings did not support the literature on the profit assumption for innovation adoption (McCue, 2000, Zinn, Weech and Brannon, 1998, and Wang, et al., 2005). Operating Income Per Admission negatively influenced the CPOE adoption decision of study hospitals.

The present paper was one of the first attempts at using organizational theory and particularly the resource dependence theory to study CPOE adoption in hospitals. Further studies can rely on the findings presented in Chapter 5 to narrow the list of potential constructs, to more parsimoniously operationalize variables for the theory, and in general to find a better fit between the theory and the data.

The lack of findings for organizational characteristics is the most striking and indicates a need for further research to find better data sources where organizational characteristics are more sharply represented for variable operationalization. Also, the environmental characteristics will need to be further refined. Real market areas for the individual hospitals might need to be better defined to gain better contrast in the models.

Limitations and Future Research

Some of the limitations are inherent in the data sources used. A more complete AHA database might have resulted in more statistical findings for the organizational variables. However, substitution of missing values with averages for the various continuous independent variables did not change the data significantly (this analysis was not reported in Chapter 5). Future research might want to focus on conducting extra data collection, such as survey conducted with hospital executives to rectify this limitation.

A factor analysis could be useful in future research to create more parsimonious constructs. This could alleviate the problem of the minimal statistical findings for variables representing the organizational characteristics. (Simple elimination of variables Size and Number of Services Offered did not result in significantly improved model fit as was reported in Chapter 5.

Using only the resource dependence theory enforced limitations on the study. Adding other theories, most notably financial theories, could help to better tailor the models to the reality of IT implementations in the healthcare sector. Future research could add financial theories or other organizational theories when developing hypotheses.

Using Leapfrog's survey data as the only primary data source limits the study to analyze only Metropolitan Statistical Areas. Rural hospitals are not represented in the study population, and this limits the generalization of study findings. In addition, only the first two waves of Leapfrog rollouts were analyzed.

Observational study design has its limitations as were mentioned in Chapter 4. The most important limitation of cross-sectional observational design is differentiating cause and effect from simple association. In optimal circumstances, future research would try to actively participate in the intervention phase of the study and maybe even in the planning of the rollout areas.

A time series analysis might be useful to find more information about the sequence of events that can lead to hospitals' CPOE adoption decisions. Future research could follow up the study hospitals and investigate what proportion of Good Early Stage

Effort and Good Progress hospitals moved ahead with their planned CPOE implementations. For the next study the present paper could serve as a comparison basis.

Additional limitation was introduced by creating the binary dependent variable Adopters. Grouping together Fully Implemented, Good Progress and Good Early Stage Effort hospitals introduced potential further limitation in the study. The significance of the latest limitation cannot be assessed by using the Leapfrog data set as only primary data source.

Also, a follow-up analysis of not responding hospitals and non-adopters of the first few waives of CPOE rollout could reveal whether or not they became involved in the CPOE adoption process eventually. Data of more details and a wider time range of the rollouts could help to further improve the model fit on its own by providing sharper "contrast."

Conclusion

The study analyzed hospitals' compliance with the Leapfrog Group's CPOE safety measure in the first two rollout periods. Organizational, financial, operational and environmental characteristics of hospitals were studied, using a resource dependence theory-based theoretical framework and logistic regression statistical methods.

The models provided support for multiple hypotheses for both the adoption and early adoption decisions of study hospitals. The operational characteristics of ownership, in-house physician staff, case mix index and the environmental characteristic of HMO penetration rate had a positive effect on management decisions. The operational characteristic excess capacity, the organizational characteristic community orientation, the financial characteristic of Operating Income per Admission, and the environmental characteristic of number of HMO contracts had a significant negative effect on CPOE adoption decisions.

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Appendices

Appendix A.

Leapfrog Member Organizations

Aetna

Allscripts Healthcare Solutions

American Century Services Corporation

American Federation of Teachers

American Medical Systems

American Re-Insurance Company

AmerisourceBergen Corporation

ArvinMeritor, Inc.

AstraZeneca

AT&T

The Auto Club Group

Aventis Pharmaceuticals Inc.

Bath Iron Works Corporation

Becton, Dickinson and Company

Bemis Company, Inc.

Blue Shield of California

Board of Pensions of the Presbyterian Church (U.S.A.)

The Boeing Company

Brown Shoes

Buyers Health Care Action Group

Cargill, Inc. Carlson Companies

Caterpillar Inc.

Centerpoint

Ceridian Corporation

Cerner Corporation

Charter Communications

Chicago Business Group on Health

CIGNA Corporation

Aetna

Allscripts Healthcare Solutions

American Century Services Corporation

American Federation of Teachers

American Medical Systems

American Re-Insurance Company

AmerisourceBergen Corporation

ArvinMeritor, Inc.

AstraZeneca

AT&T

The Auto Club Group

Aventis Pharmaceuticals Inc.

Bath Iron Works Corporation

Becton, Dickinson and Company

Bemis Company, Inc.

Blue Shield of California

Board of Pensions of the Presbyterian Church (U.S.A.)

The Boeing Company

Brown Shoes

Buyers Health Care Action Group

Cargill, Inc.

Carlson Companies

Caterpillar Inc.

Centerpoint

Ceridian Corporation

Cerner Corporation

Charter Communications

Chicago Business Group on Health

CIGNA Corporation

Cisco Systems, Inc.

CITIGROUP INC.

Cleveland State University

Comerica

The Commonwealth of Massachusetts, Group Insurance Commission

Coors Brewing Company

Cummins Inc.

DaimlerChrysler Corporation

Delta Air Lines, Inc.

The Department of Employee Trust Funds and State of Wisconsin Group Insurance

The Doe Run Company

The Dow Chemical Company

Eastman Kodak Company

Eclipsys Corporation

Electronic Data Systems

Eli Lilly and Company

EMC Corporation

Empire Blue Cross and Blue Shield

Employer Health Care Alliance Cooperative (The Alliance)

ESCO Technologies, Inc.

Excellus Inc.

Exxon Mobil Corporation

FedEx Corporation

Fidelity Investments

Fisher Scientific International

Fleet Boston Financial

Flint Ink

Ford Motor Company

General Electric Company

General Mills, Inc.

General Motors Corporation

Georgia-Pacific Corporation

GlaxoSmithKline

Hannaford Bros. Co.

HCA

Health Alliance Plan

Health Language

Health Net Inc.

HealthPartners

Health Plan of Michigan

HealthPlus of Michigan

Health Services Purchasing Coalition

HIP Health Plan of New York

Honeywell Inc.

Horizon Blue Cross Blue Shield of New Jersey

IBM

IDX Systems Corporation

Intel Corporation

International Association of Machinists and Aerospace Workers

International Paper Company

Johnson Controls, Inc.

Johnson County, Kansas

Josten

JSA Healthcare Medical Group

Kellogg Company

The KNW Group

Land O' Lake

LG&E Energy Corporation

Lockheed Martin Corporation

Lucent Technologies

Maine Municipal Employees Health Trust

Maine State Employee Health Commission

MaineHealth

Marriott International, Inc.

M-Care, Inc.

McKesson Corporation

MDanywhere Technologies Inc.

The Mead Corporation

Merck & Co., Inc.

Meridian Automotive Systems, Inc.

Microsoft Corporation

Minnesota Life

Minnesota Mining & Manufacturing Company (3M)

Misys Healthcare Systems

Monsanto Company

Motorola, Inc.

MVP Health Care

National Education Association

National Rural Electric Cooperative Association

Nevada Health Care Coalition

New Jersey Health Care Quality Institute

New Jersey State Health Benefits Program

New York Business Group on Health

North Carolina Teachers' and State Employees' Comprehensive Major Medical Plan

Northwest Airlines, Inc.

Olin's Brass and Winchester Divisions

Oxford Health Plans, Inc.

Pacific Business Group on Health

Pediatrix Medical Group Inc.

PepsiCo

Pillsbury Company

Pitney Bowes Inc.

The Procter & Gamble Company

Promina Health System, Inc.

Quality Systems Inc.

Quest Diagnostics

Qwest Communications International Inc.

Ramsey County

Robert Wood Johnson University Hospital

Robert Wood Johnson University Hospital at Hamilton

Ryder System, Inc.

St. Louis Area Business Health Coalition

Savannah Business Group

Schering-Plough Corporation

Siemens Corporation

Solutia, Inc.

Southern California Schools Voluntary Employees Benefits Association

Sprint Corporation

State of Kansas Division of Personnel Services

Supervalue Inc.

Target Corporation

TCF Financial Corporation

Tennant Company

Textron Inc.

TI Automotive

Trinity Health Plans

Tufts Health Plan

Union Pacific Railroad

Union Pacific Railroad Employes Health Systems

United Parcel Service

UnitedHealth Group

University of Maine System

Verizon Communications

Washington Mutual Bank

Washington State Health Care Authority

Wausau Benefits, Inc.

WEA Trust

Wells Fargo

Wiseman and Associates Financial Services, LTD

Xcel Energy

Xerox Corporation

Appendix B.

2004 Computer Physician Order Entry (CPOE) Leap

Each hospital fulfilling this Leap:

1. Assures that prescribers* enter hospital medication orders via a computer system that includes decision support software to reduce prescribing errors;

2. Demonstrates, via a test (now under development by the First Consulting Group and the Institute for Safe Medication Practices), that their inpatient CPOE system can alert physicians to at least 50% of common serious prescribing errors. This criterion for the leap will not count towards your hospital's publicly reported status on this leap until the test is available; and,

3. Requires that prescribers electronically document a reason for overriding an interception prior to doing so.

"Prescribers" used throughout this section refers to all clinicians authorized by the hospital to order pharmaceuticals for patients.

Additional Information about the Leapfrog Group:

FactSheetCPOE.pdf

Bibliography: BiblioCPOE.pdf

1) Does your hospital have a functioning CPOE system in at least one unit?

Yes

No

2) If Yes, what percent of your hospital's total medication orders (including orders made in units which do NOT have a functioning CPOE) do prescribers enter via a CPOE system that:

• includes decision support software to reduce prescribing errors;

• is linked11 to pharmacy, laboratory, and admitting-discharge-transfer (ADT) information in your hospital; and,

• requires that they document electronically a reason for overriding an interception prior to doing so?

_____%

3) What percent of inpatients have the majority of their medication orders entered by a prescriber via a CPOE system?

If you answered "No" to question #1, or less than 75% to question #2, please answer questions # 4-11 below as a means of sharing the interim steps your hospital may be taking.

4) If your hospital does not have a CPOE system installed that meets the Leapfrog CPOE Leap, please check the box at right that best describes your current stage in CPOE planning and implementation:

Planning for CPOE

Currently selecting CPOE system

(at a minimum, RFP has been released)

Currently implementing a CPOE system

None of the above

5) Do you have a written strategy for implementing CPOE?

Yes

No

6) Have you defined a timeline and launched a CPOE implementation project?

Yes

No

7) What is the date, if any, by which your hospital commits to meet the Leapfrog CPOE leap fully?

MMYYYY

e.g. 062007

8) Has your hospital's board approved a dedicated budget for CPOE for the latest fiscal year for which it approved a final budget?

Yes

No

9) Do you have a physician champion who spearheads the CPOE initiative at your hospital?

Yes

No

10) Is your CPOE strategy a component of a larger written strategy for a clinical information system?

Yes

No

11) For hospitals with 100 or more beds: Does your hospital have an in house pharmacist available 24hrs/day, seven days/week, to review orders prior to initial dispensing of medications?

Yes

No

Affirmation of Accuracy

These statements pertaining to the Computer Physician Order Entry (CPOE) leap at our hospital are accurate and reflect the current normal operating circumstances at our hospital. I am authorized to make these statements on behalf of our hospital. We understand that The Leapfrog Group and its participants will make this information or analyses of it public, and that they reserve the right to omit or disclaim information that is not current.

Affirmed by ____________________, the hospital's __________________________,

(name) (title)

on ______________________.

(date)

Vita

Imre Solti was born on August 21, 1968 in Szolnok, Hungary and is an American citizen. He graduated from Tisza High School, Szolnok, Hungary in 1986. He received his M.D. from Albert Szent-Gyorgyi Medical University in 1992, Szeged, Hungary. He worked in the Medical Biology Department of the Albert Szent-Gyorgyi Medical University. Before moving to the USA, he attended the Health Care Management Institute in Budapest, Hungary where he received his Diploma in Health Administration in 1996.