WHY PHYSICIANS DO OR DO NOT USE COMPUTERIZED PHYSICIAN ORDER ENTRY SYSTEMS: APPLYING THE TECHNOLOGY ACCEPTANCE MODEL

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ABSTRACT

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This study addresses post-implementation usage behavior of Computerized Physician Order Entry (CPOE) system among physicians in an organization by applying the Technology Acceptance Model (TAM). Implementation of CPOE is considered a major organizational activity by chief information officers (Kini & Savage, 2004), and physician acceptance of CPOE ultimately decides the success of CPOE implementation (Davis, 1989). Hence, this study assumes much importance. A CPOE-TAM instrument was developed for this study and assessed with principal component analysis. Six hypotheses were developed and tested using hierarchical multiple regressions.

Study results suggest that the '*total causal effects*' of perceived usefulness of CPOE (PU) and perceived ease of use of CPOE (PEOU) on behavioral intention to use CPOE (BI) and CPOE adoption are striking, and PU is more important than PEOU in their relative influence on BI and CPOE adoption. Implications of the findings suggest that training sessions need to emphasize 'usefulness' of CPOE and any increase in ease of use features of CPOE would directly influence usefulness of CPOE, which in turn influence BI and CPOE adoption.

Studying the adoption of CPOE within an organizational context among physicians by applying TAM contributes richly to research literature in these major domains. This CPOE-TAM study was well-validated, and a parsimonious CPOE-TAM instrument is now available to information system and human-computer interaction researchers and practitioners. This CPOE-TAM instrument could be split further into two instruments: one for prediction of future acceptance of CPOE, and the other for explanation of CPOE adoption.

While I am extremely pleased to dedicate this dissertation to my ever loving children, daughter Kritika and son Wignaesh, I am equally blessed to dedicate this doctoral degree in leadership studies to my ever loving parents, mother Rajeswari and father Sachidanandam.

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Amma, after you got married to my father, who allowed you to complete high school and graduate in spite of obtaining your motherhood, a taboo in India those days as well as now. You faced the adversities with pride and with a sense of commitment, and essentially laid a foundation for your future children's education. You are one of the most courageous women I have ever known. If at all your four sons are good in mathematics and science, it is due to your coaching. *Amma,* with your high school knowledge, you taught us Science, Algebra, and Geometry at the same grade level. What a confidence you had in you.

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CHAPTER I. INTRODUCTION

Statement and Description of the Problem

The Importance of Computerized Physician Order Entry System

Physicians who use paper-based medical records are constrained from sharing medical information of their patients with their colleagues unless their medical records are copied and hand-carried, mailed, or faxed to them (Goldsmith, Bluementhal, & Rishel, 2003). These constraints pose a significant barrier for physicians in providing timely needed services for their patients. The same is true in rendering services such as ordering medications and laboratory tests. Goldsmith et al. (2003) further added that the Institute of Medicine of the National Academies, United States of America, advisers to the nation on science, engineering, and medicine, pointed to the poor information management at the hospitals and clinics as a major cause for the unacceptably high level of medical errors in the United States. Various studies have supported the need for better information management in hospitals. For example, a study conducted at the Brigham and Women's Hospital of Harvard Medical School found out that the rate of serious medication errors was reduced by 55 percent after the introduction of Computerized Physician Order Entry (CPOE) system (Bates et al., 1998).

All Electronic Medical Records (EMR) do not have the advanced features of CPOE (Rehm & Kraft, 2001). CPOE is a software application that initiates care through orders for therapy and procedures (Kini & Savage, 2004). CPOE helps to order tests, medications, and treatments. CPOE also helps to streamline the workflow as the information is transferred electronically to the laboratories, pharmacies, etc. CPOE would eliminate illegible and incomplete prescriptions and flag contraindications and potentially dangerous treatments (Rehm & Kraft, 2001). Medication errors form 19% of all adverse events in patient management, and although adverse medication errors can happen at any level in the treatment process, the literature has shown that errors caused from ordering medications are mainly responsible for the majority of adverse events (Kini & Savage, 2004). Kini and Savage added that the average additional cost for an adverse drug-related event among in-patients is $2500, and the average liability claim for an adverse drug-related incident is $376,000. Kohn, Corrigan, and Donaldson (1999) estimated deaths due to medical errors between 50,000 and 100,000 in each year, and a significant portion of the deaths was due to adverse drug-related events. Thus, using CPOE in practice would appear to help reduce medication-ordering errors, liability claims, and save lives among other useful features (Bates et al., 1998; Goldsmith et al., 2003; Kohn, Corrigan, & Donaldson, 1999).

Leadership Challenges

Several research studies have suggested that implementing CPOE at the healthcare systems and hospitals in the United States could potentially improve the quality of healthcare in this country (Bates et al., 1998; Goldsmith et al., 2003). Therefore, hospitals and the healthcare systems in the United States are under pressure now to install the CPOE system, successfully implement it, and enable physicians to adopt the same. In order to achieve this, each medical record must first be converted from the paper medium to the electronic medium. Blodgett (1997) stated that changing from paper-based medical records to electronic medical records has not received the needed push because of lack of government involvement. However, in 1996 the Kennedy/Kassebaum Health Care Reform bill was passed by Congress and later signed into a law (Blevins, October, 2002; Blodgett, 1997). The Act, known as the Health Insurance Portability and Accountability Act of 1996 or HIPAA, established standards for privacy, security, and electronic data interchange of health information. One of the important requirements of HIPAA is that healthcare and medicine professionals follow standardized formats for all information exchanges, known as Transaction Standard.

Implementing information technology fully in all the healthcare systems, hospitals, and physicians' offices in the United States could save 87 billion dollars annually, and break revenues in the fifth year and make a total of $395 billion net returns by the tenth year (Morrissey, 2004). Morrissey further added, however, that implementing CPOE is expensive as the initial cost could be between $4 million and $7 million for a medium-sized general hospital. One could well imagine the magnitude of the monetary investments if all United States' hospitals, physicians' offices, and health systems implemented CPOE. CPOE is considered important for better healthcare delivery as all EMRs do not have the advanced features of CPOE (Rehm & Kraft, 2001).

Although several private vendors have been marketing the Electronic Medical Record (EMR) since the 1980s, there is recent increased activity in the development of EMR (Rehm & Kraft, 2001). In addition, not all EMRs have the CPOE capability and only selected vendors offer EMR with CPOE. Government involvement, notes Rehm and Kraft, might have provided a much needed guarantee, indirectly, which is undoubtedly a good sign for the future development of CPOE. Further, the amount of projected savings in expenditure and increases in revenue are additional factors that drive the healthcare industry to implement these initiatives (Morrissey, 2004). A Chief Information Officer (CIO) leadership survey conducted by the Superior Consulting Group in February 2003 and Deloitte and Touche in fall 2002 found that more than 60% of CIOs intended to implement CPOE in the next two years, and considered CPOE as a major future organizational activity (Kini & Savage, 2004). It is critical that the senior management at hospitals and healthcare systems identify ways to overcome barriers to implementing and adopting CPOE (Poon, Blumenthal, Jaggi, Honour, Bates, & Kaushal, 2004). Venkatesh and Davis (2000) also observed that new information technology implementation and adoption is still a matter of concern in many organizations as many systems installed are underutilized.

Problems with CPOE System Implementation

The 850-bed Cedars-Sinai hospital management in Los Angeles introduced a CPOE system in November 2002 to be implemented in a 14-week period with the instructions that physicians must enter orders electronically or lose staff privileges (Versel, 2004). Losing staff privileges meant losing the potential to earn more money. In spite of that threat, the physicians revolted against using CPOE protesting that the system was difficult to use, very slow in functioning, and was not useful to their medical practice. In addition, the physicians claimed there were problems with clinical workflows. Versel further said that in January 2003, the management shut down the CPOE system, and later the management of parent organization of Cedars-Sinai Health System scrapped the implementation of CPOE totally. The implementation of CPOE failed because the physicians at Cedars-Sinai hospital in Los Angeles perceived that CPOE system was "neither easy to use nor useful" in their medical practice. Even if all the relevant issues of implementation of CPOE such as organizational, technical, privacy and security are addressed, the implementation of CPOE could fail if physicians reject the implemented CPOE system.

The Role of CPOE System in Facilitating Medication Errors

The majority of the studies about CPOE examine its benefits, especially in reducing prescription errors (Bates et al., 1998; Kohn et al., 1999; Koppel et al., 2005). However, since very few researchers have focused on the negative side of CPOE, Koppel et al. undertook a study to find out whether CPOE facilitated prescription error risks. The study was conducted in a major teaching hospital with 750 beds and 39,000 annual discharges. The hospital used a CPOE system from 1997 to 2004 and obtained the system from a major vendor that had 60% of the CPOE system market.

Koppel et al. (2005) conducted a detailed quantitative and qualitative study that incorporated structured interviews with personnel from all coordinating departments, and observations of physicians writing medication orders, nurses charting medications, and pharmacists reviewing the medication orders. The researchers found that CPOE facilitated as many as 22 types of medication error risks, and concluded that physicians have to attend to these possible medication errors that the CPOE system causes, in addition to the errors it is supposed to prevent. The errors included human-machine interface and workflow problems that are not consistent with usual work behaviors. Study results suggested that the system was not very *useful or easy to use* by medical personnel. The researchers also pointed out that these CPOE problems would have escaped the required attention because the medical personnel knew how to work around the system's problems. In case of problems, the medical personnel would have used the conventional way of ordering through papers, bypassing the system. For the medical personnel patient care was far more important, and they would achieve that with the easiest and fastest available route.

Clinician Interaction and Resistance to Change

Physicians required to use the CPOE system for orders may have many legitimate concerns in adapting to a new technology. Chau and Hu (2002) opined that physicians are more likely to practice medicine in the way they were trained, and so their role in the implementation process of inter-organizational healthcare information systems is critically important. Further, physicians feel that technology is distancing them from patients, leading patients to describe them as cold in personal interactions (Magenau, 1997). Magenau added that like patients, physicians also want to retain the face-to-face interaction in the way they were trained, yet another reason for physicians to resist CPOE in their practice. Moreover, physicians have unfavorable attitudes to implementing clinical information systems in their practice that are bound to interfere with their routine work (Anderson, 1997; Anderson & Aydin, 1997). Further, implementation of clinical information systems in medical practice also undermines the autonomy of physicians as their workflow and decision making are governed by the systems.

Although physicians could be blamed for resisting the implementation of a new clinical information system, it could be argued that they are fully justified in resisting the use of faulty clinical information system that facilitates medication errors in their practice (Koppel et al., 2005). What are the physicians supposed to do if the system is faulty, difficult to use, or not useful to effective practice? What approaches should the physicians take if the system interferes with their workflow and causes delays in placing orders for the ailing patients? Under these circumstances, is it appropriate to resist the new technology implementation? Therefore, the management and the implementation team should acknowledge the problems faced by physicians in working with clinical information systems and resolve the issues. Versel (2004) argued that using the authority and power to implement the same would result in a situation similar to physicians' revolt against using the CPOE at Cedars-Sinai hospital in Los Angeles and could potentially lead into an implementation failure.

Resistance as a Positive Force

Humans resist changes, and physicians are no exceptions. Among many other things discussed above, physicians' resistance to accept technology is a factor that could further restrict the implementation of CPOE and other electronic information systems. Karp (1996) stated that though there is an association between change and resistance, it is not always a cause-and-effect situation as people often believe. He further stated that resistance needs to be honored and worked with, as resistance is an organizational asset; it provides new information and brings the potential pitfalls of the change process to the organization's attention. While dismissing the three most often used strategies of dealing with resistance, namely breaking resistance down, avoiding resistance, and minimizing resistance, Karp firmly advocated treating resistance as a positive force and allowing resistance issues to surface rather than to be buried.

Approaches to CPOE System Problems

Employees' use of computer information systems is mandatory in the airline industry (Roberts & Henderson, 2000). The mandated use of computer information systems by the employees could be one of the reasons for successful adoption of the information system in the airline industry, as Brown, Massey, Montoya-Weiss, and Burkman (2002) argued that employees, in order to retain their jobs, would use the available information system regardless of their negative or positive affect toward the system. This means that the employees in these organizations failing to adopt the computer information system in the workplace have to leave their job because the only way one can perform the job is to do so through the computer information system. The question arises whether hospital management could take a similar approach and make the use of CPOE by physicians mandatory in the workplace. This may not happen in the near future since CPOE implementation in hospitals is still in its infancy and the system is going through continuing evolution to improve the performance. As of 2002, only 9.6% of U.S. hospitals have the CPOE system completely available (Ash, Gorman, Seshadri, & Hersh, 2004). One could argue that if a sizeable percentage, say around 50% and above, of the U.S. hospitals started using the CPOE system, there would be a possibility that the usage of the system could be mandated. Otherwise, physicians could leave the organizations that use CPOE to seek jobs elsewhere where CPOE usage is not mandated.

Moreover, the studied CPOE system facilitated 22 types of medication errors, occurring frequently, and the physicians have to work around the system to attend to errors that the system cause, in addition to errors they prevent (Koppel et al., 2005). This *work-around* approach by physicians is indeed often necessary to provide efficient and timely patient care as implementation of a CPOE system does not necessarily guarantee the efficient use of the system. With so many problems faced by physicians using CPOE and the necessity and ability to work around the CPOE system, it is less possible to mandate the use of CPOE by physicians. Neither the mandated use of the CPOE system nor the requirement to use the system with coercion (Versel, 2004) would make the physicians adopt the CPOE system in their practice. The prospect of physicians adopting the CPOE system in their practice largely depends on their acceptance of the system and their willingness to use the system (or, willingness to perform the *behavior)* in an efficient manner. Acceptance, willingness, and performance are in turn dictated by the *ease of use and usefulness* of the implemented system as perceived by physicians and not as purported by the proponents of the CPOE system.

The ability to develop new technology alone is not sufficient for success of any technology, but the acceptance of that technology by the *users* ultimately decides the success of any implemented technology (Davis, 1989). The above concept is based on an important and fundamental business principle: The product(s) of any business must be acceptable and must satisfy the end-users or consumers if the business is to survive. With respect to the present study, this business principle and the adoption of CPOE are explored through the Technology Acceptance Model.

Theoretical Background

Origins of Technology Acceptance Model

Research into factors that predict Information Technology (IT) acceptance has received much attention because a major goal for many organizations is IT adoption and use (Money & Turner, 2004). The Technology Acceptance Model (TAM) is one such research model. Fred Davis developed TAM in the mid-1980s under contract with IBM Canada to evaluate the market potential and product development for emerging personal computer-based applications in the areas of multi-media, image processing, and pen-based computing (Davis & Venkatesh, 1996). TAM is specifically designed to study IT-adoption and use, and to predict and explain user acceptance of information technologies (Davis, 1993; Morris & Dillon, 1997). With TAM, researchers and practitioners can identify why a particular system may be unacceptable to the users, and pursue appropriate corrective steps (Davis, Bagozzi, & Warshaw, 1989).

TAM has origins in the Theory of Reasoned Action (TRA), articulated by Fishbein and Ajzen in 1975 (Davis, 1993; Davis et al., 1989; Morris & Dillon, 1997). TRA is a model from social psychology, which is concerned with the determinants of consciously intended behaviors. TRA postulates that intentions to perform a behavior are a function of two basic determinants, one personal (attitude toward the behavior) and the other reflecting social influence (subjective norms). Subjective norms are defined as the person's beliefs that specific individuals or groups approve or disapprove of performing the behavior (Roberts & Henderson, 2000). TRA posits that people would perform a specific behavior such as using computers, if they believe that it would lead to positive outcomes associated with using them (Compeau & Higgins, 1995). The behavioral intentions to use actually lead to actual system usage.

TAM has deep roots from a wide variety of theories such as the adoption of innovations, the cost-benefit paradigm, expectancy theory, and self-efficacy theory (Davis, 1989). The main goal of TAM is to provide an explanation of the determinants of computer acceptance and user behavior across a broad range of end-user computing technologies and user populations (Davis, 1989; Davis, 1993; Davis et al., 1989).

Original Technology Acceptance Model

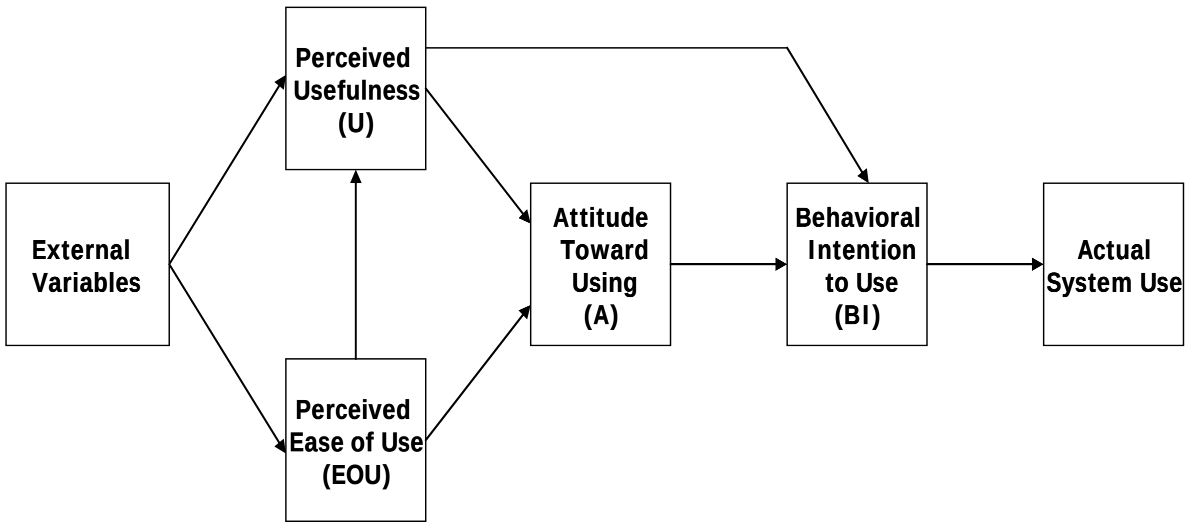
TAM posits that system design characteristics, quality of the system, and training are among the external stimuli (variables) about which the user formed certain cognitive responses (Davis, 1993; Davis et al., 1989; Davis & Venkatesh, 1996). These responses are *perceived usefulness* and *perceived ease of use* of the system; and they are of primary importance and relevance for computer acceptance behaviors (Davis et al., 1989):

> Perceived usefulness (PU) is defined as the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context. Perceived ease of use (PEOU)

> refers to the degree to which the prospective user expects the target system to be free of effort. (p. 985)

Further, PEOU also has a causal effect on PU, and factor analyses suggest that PU and PEOU are statistically distinct dimensions (Davis et al., 1989). The two variables PU and PEOU are, in turn, predicted to be linked to the affective response that is the attitude (A) toward the use of the system and to behavioral intention (BI), and ultimately the actual user behavior: use of the system or rejection of the system (Davis et al., 1989). In addition, TAM also proposes a direct relationship between perceived usefulness and the behavioral intention to use (Morris & Dillon, 1997). System acceptance is defined by researchers as the potential user's predisposition toward personally using a specific system, and system acceptance leads to system usage (Davis, 1993; Davis et al., 1989; Morris & Dillon, 1997). The ultimate objective of TAM is to measure and explain the system usage behavior. (Davis et al., 1989; Legris, Ingham, & Collerette, 2003). TAM posits that the influences of external stimuli are mediated through PU, PEOU, and BI leading to performance of the behavior: actual system usage. See Figure 1 for a visual representation of Davis' (1989) TAM.

Figure 1. Original Technology Acceptance Model.[1]



The causal chain linking external variables to actual use via the mediating variables namely perceived ease of use, perceived usefulness, attitude toward using, and behavioral intention to use.

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[1]From "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," by Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). *Management Science, 35*(8), p. 985.

Revised Technology Acceptance Model

Davis and Venkatesh (1996) stated that the variable "attitude" in the original TAM is irrelevant in many work situations where tasks can now be undertaken only on a computer (e.g., airline booking clerk). Therefore, attitude cannot be taken as a true predictor responsible for a person's behavioral intention to use (Roberts & Henderson, 2000). Moreover, in many work settings people may use a technology even if they do not have a desire or positive attitude (affect) toward using it. Instead, they may simply perceive it as useful for productivity enhancement (Davis & Venkatesh, 1996). Further, based on empirical evidence, Davis and Venkatesh excluded the attitude construct in the revised TAM, because attitude did not fully mediate the effect of perceived usefulness on intention to use the system.

User Acceptance

Davis (1989) mentioned that performance on the job depends upon the level of the acceptance of new information systems; performance is lost when the acceptance is low or rejected by the end-users. In addition, user friendliness of the system also has an impact on the user acceptance. Thus, job performance and user friendliness of a new technology or system in the workplace jointly influence the user acceptance of the given technology or system. Lack of user acceptance has been an obstacle for the success of new information systems' implementation (Davis, 1993). Therefore, physician acceptance of CPOE, for example, is most critical for successful implementation, adoption, and use of CPOE. The transition from paper-based medical records to a CPOE system would be smooth if the implemented system is perceived *useful* by the physicians to increase their job performance and productivity. It is equally important that physicians also perceive the system as *easy to use* because all of them may not be experts in using computer applications. Shortliffe (1997) noted that physicians have started using applications over the Internet such as WebMedline, CliniWeb, Dxplain, and MedWeaver to improve their knowledge in medicine. This is a valuable experience for physicians as that could enable them to adopt and use the CPOE system with relative comfort, since they would not be inexperienced customers to using computers.

TAM Studies in Information Technology Adoption

The Technology Acceptance Model was developed to evaluate user acceptance of technology by assessing users' beliefs, attitudes, intentions, and actual computer adoption behavior (Croteau & Vieru, 2002; Davis, 1989; Davis et al., 1989). According to TAM, the two central belief constructs *ease of use* and *usefulness* chiefly influence Information Technology (IT) adoption (Gefen & Straub, 2000). Davis postulated and found that the *behavioral intention to use* information technology was strongly correlated with the *use* and explained a specific behavior *(usage*) toward a specific target computer application (Davis et al., 1989). Although researchers have used either the *behavioral intention to use* or *system usage* as their dependent variable in their studies, their goal was to explain the information technology acceptance, adoption, and usage (Chau, 1996).

For example, several researchers have used *behavioral intention to use* as their dependent variable (Amoako-Gyampah & Salam, 2004; Brown, Massey, Montoya-Weiss, & Burkman, 2002; Chau & Hu, 2002; Hu, Chau, Liu Sheng, & Tam, 1999), deleting the *system usage* variable to predict and explain technology acceptance, and usage.

Researchers have even used *intention to use IT* as the dependent variable to study *IT-adoption decisions* in small businesses (Riemenschneider, Harrison, & Mykytyn Jr, 2003). Researchers have also operationalized the dependent variable *adoption decision* as *intention to use* the system in the future (Agarwal & Prasad, 1998). While Agarwal and Prasad opined that the extent of actual use is a good measure of adoption success, they have used the *intentions to use* as the dependent variable, because of the timing of data collection, to study the *adoption decision* of an implemented system. The researchers noted that this approach was consistent with past research findings that the actual use is predicted by the intentions to use, and they observed that potential adopters would have made an *adoption decision* at the time of the implementation of a system even if they did not have an opportunity to start using the system.

Within TAM, the *behavioral intention to use or the system acceptance*, defined by researchers as the potential user's predisposition toward personally using a specific system, is the *single best predictor of system usage* that leads to *actual system usage* (Davis, 1993; Davis et al., 1989; Morris & Dillon, 1997). In other words, intention to use the system implies that the system in question has gained the acceptance of the user that leads to adoption of the system and system usage by the user. In addition, in many TAM studies, *System usage* and *IT-adoption* are used interchangeably as the dependent variable conveying the same meaning and purpose implying that users have to accept the technology and adopt it to use (Chau, 1996). Regardless of the view, consistent with the Davis et al. (1989) study that introduced the technology acceptance model, the present study of physician acceptance of CPOE will use *behavioral intention to use* as a *mediating variable* fully mediating the effects of *ease of use and usefulness* on *system usage.* In this study, the dependent variable *system usage* is used as a surrogate for *CPOE adoption*. The variables or constructs used in this study are discussed in detail in Chapter 2

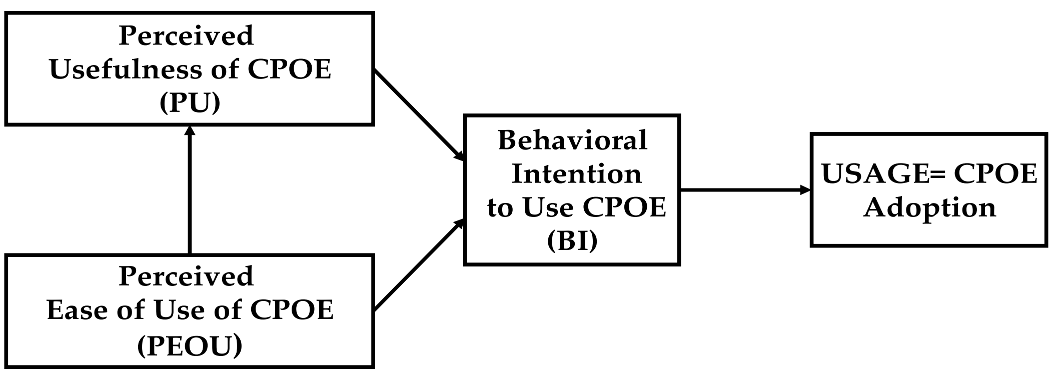
Purpose of the Study

The primary purpose of this study is to apply a revised TAM in order to predict and explain the extent to which the CPOE system is perceived as *useful and easy to use* by physicians, and whether it has been well accepted, adopted, and used by them in their medical practice. In doing so, the researcher also intends to apply TAM from the physicians' perspective within an organizational context. The other objectives of this study are to examine and explain the *perceptions-behavioral intentions-behavior relationship within TAM,* and test various hypotheses based on these relationships. This will further help researchers and practitioners understand the information technology acceptance behavior of physicians in a healthcare organization.

Proposed Model for this Study

Ease of Use (PEOU) and Usefulness (PU) are the two central constructs of TAM; and their relative impact on behavioral intention to use the system and usage of the system are of importance in studying the acceptance of an information system (Davis, 1989). The four constructs of TAM, namely perceived ease of use (PEOU), perceived usefulness (PU), behavioral intention to use (BI), and system usage will be examined within the TAM as the causal chain links the variables PEOU and PU to system usage, the surrogate for CPOE adoption, via the mediating variable BI. See Figure 2.

Figure 2. Revised Technology Acceptance Model Adapted for this Study



The causal chain linking the variables perceived ease of use and perceived usefulness to system usage, the surrogate for CPOE adoption, via the mediating variable behavioral intention to use.

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[2]From several “Technology Acceptance Model” studies.

In many empirical studies, the theorized external variables of TAM, such as system design characteristics, training, documentation, other types of support, etc. were not studied independently but rather the external variables' *collective* influence on behavioral intentions and system usage mediating through PU and PEOU was studied (Adams, Nelson, & Todd, 1992; Bajaj & Nidumolou, 1998; Davis, 1989; Davis, 1993; Davis et al., 1989; Hu et al., 1999; Morris & Dillon, 1997; Straub, Limayem, & Karahanna-Evaristo, 1995; Szajna, 1996; Taylor & Todd, 1995a). A detailed review of TAM and associated Information System (IS) research literature will be reviewed in Chapter 2.

Overview of TAM Constructs or Variables

The two important belief constructs or variables, perceived Ease of Use (PEOU) and perceived Usefulness (PU), are the main pillars of the TAM. In this model, PEOU and PU are first dependent variables with respect to all external variables. In addition, PU is also a dependent variable to PEOU. PEOU and PU are, in turn, independent variables with respect to the next dependent variable, Behavioral Intention to use (BI). PEOU and PU, with relative weights, jointly influence BI. BI, in turn, is an independent variable to system usage, the surrogate for CPOE adoption, another dependent variable of this study. PEOU, PU, and BI are also classified as intermediate or mediating variables since the effects of other variables are mediated though them. Since the external variables are not measured in this study and for the purpose of clarity, the external variables are not shown in the proposed model as in Figure 2. The constructs or variables of this model will be discussed in detail in Chapter 2.

Research Questions

The main research questions addressed in the study are given below.

1. What are the constructs or variables that influence the physicians' use of the Computerized Physician Order Entry system (CPOE)?
2. What are the relationships among the constructs or variables that influence physicians' use of CPOE?

Research Hypotheses

Based on the revised TAM, as shown in Figure 2, and its description, the following research hypotheses will be tested.

H1: Perceived *ease of use of CPOE* will have a significant positive influence on perceived *usefulness of CPOE.*

H2: Perceived *ease of use of CPOE* will have a significant positive influence on *behavioral intention to use CPOE.*

H3: Perceived *usefulness of CPOE* will have a significant positive influence on *behavioral intention to use CPOE.*

H4: *Behavioral intention to use CPOE* will have a significant positive influence on *CPOE usage.*

H5: *Perceived ease of use* and *usefulness of CPOE* will have a significant combined positive influence on *behavioral intention to use CPOE.*

H6: *Perceived ease of use* and *usefulness of CPOE* will have a significant combined positive influence on *CPOE usage.*

Overview of Research Methodology

The above hypotheses will be tested through a survey of physicians practicing in a non-profit healthcare organization in Minnesota (see Appendix A). Previously validated scales that have been empirically tested with many TAM studies will be used to measure all the identified constructs, namely perceived usefulness, perceived ease of use, behavioral intentions to use and user acceptance. Consistent with other research studies that applied TAM (Bajaj & Nidumolou, 1998; Davis, 1989; Davis, 1993; Davis et al., 1989; Szajna, 1996; Venkatesh & Davis, 2000), regression analysis will be performed in this study. Specifically, hierarchical multiple regressions will be used to assess the model and the independent influence of each construct (Morris & Dillon, 1997) on the physician acceptance of CPOE. Morris and Dillon argued that hierarchical regression analysis permits the researcher to control other variables in the model when examining the specific contribution of each variable in the model. Moreover, in hierarchical multiple regression, the researcher, not the computer, determines the order of entry of the variables. It is important to use this technique to define the order of entry of variables when the study is based on a theory. Hierarchical regression is used in models such as TAM that may involve a series of intermediate variables, which are dependents with respect to some other independent variables, but are themselves independents with respect to the ultimate dependent variable. The researcher also discussed with Michael G. Morris, one of the experts in TAM, and an Associate Professor of Information Technology at the University of Virginia, and confirmed the suitability of applying TAM as well as the statistical techniques to be applied for the proposed study. The researcher has also consulted the statistical consulting center at the University of Minnesota to fine-tune the various aspects of research methodology of the proposed study. The research methodology is discussed in detail in Chapter 3.

Significance of the Study

Finding out the physician acceptance of CPOE is of paramount importance, the main purpose of this study, and it is twofold. First, if the physicians at Buffalo hospital whole-heartedly accept and adopt CPOE in their practice, it gives the management much needed assurance to go ahead with the rest of implementation at other Allina locations. Second, if there are any physician acceptance problems, it gives the management an opportunity to revisit their implementation process, and would enable them to undertake remedial actions since the ultimate goal of Allina, is to implement CPOE in its entire healthcare system. Therefore, the research study design is purposive survey.

As discussed above, there are many stakes involved in implementing an end-user technology such as CPOE, and it is very important to study the acceptance of CPOE by physicians, as they are the ones who are authorized to use CPOE in every healthcare setting. The design features of an information system or computer application or end-user information technology were tested applying TAM in many studies to predict the acceptance and use of the information system or computer application or end-user information technology in question (Adams et al., 1992; Bajaj & Nidumolou, 1998; Chau & Hu, 2002; Davis, 1989; Davis, 1993; Davis et al., 1989; Hu et al., 1999; Mathieson, 1991; Morris & Dillon, 1997; Straub et al., 1995; Szajna, 1994; Szajna, 1996; Taylor & Todd, 1995a, 1995b). Past research has also shown that many times the design features of several computer applications were tested by applying TAM to predict the acceptability of that product in the market (Davis, 1993; Davis & Venkatesh, 1996).

There is an increasing importance of end-user computing that has pushed technology acceptance as an essential activity in many organizations (Davis et al., 1989; Igbaria & Tan, 1997; Igbaria, Zinatelli, Cragg, & Cavaye, 1997). Both TRA and TAM predict intentions of use computer technology effectively; however, TAM is a much simpler and more powerful model to study the determinants of user acceptance of end-user computing (Davis et al., 1989; Igbaria & Tan, 1997; Szajna, 1994). The two journal articles that introduced TAM, namely Davis (1989) and Davis et al. (1989), were cited in

424 journal articles as of January 2000, according to Institute for Scientific Information’s Social Science Citation Index (Venkatesh & Davis, 2000). They added that TAM has proven to be a well-established robust, parsimonious, and powerful model for predicting user acceptance of computer technology. TAM is more specifically developed for explaining and/or predicting user acceptance of computer technology (Hu et al., 1999). The goal of TAM, with strong theoretical justification, was to provide an explanation of the determinants of computer acceptance and explain user behavior across a broad range of end-user computing technologies and user populations (Davis et al., 1989). Hu et al. examined TAM in the context of physician acceptance of telemedicine technology to contribute and extend the theoretical validity and empirical applicability of existing literature to healthcare professionals. Similarly, this study will also add to the existing need of explaining and/or predicting physician acceptance of CPOE as implementing CPOE is one of the most important projected activities of many healthcare organizations in future (Kini & Savage, 2004).

Scope, Limitations, and Assumptions of the Study

The scope of this study is limited to physician acceptance of the CPOE system, the single most important factor in the implementation of CPOE, and will not deal with other issues of implementation, however important they are, because such issues are secondary or become irrelevant without physician acceptance of CPOE. There are several external variables, such as system design characteristics, quality of the system, and training, that influence PEOU and PU (e.g., Davis, 1993; Davis et al., 1989; Davis & Venkatesh, 1996), but were not studied here.

All scales of measurement of items are self-reported and not observed. Although studying only CPOE acceptance of physicians attached to a non-profit healthcare organization in Minnesota, general conclusions can be drawn concerning acceptance of CPOE by other physicians who use or will be using CPOE in other healthcare organizations in the United States. TAM is a predictive model and not a descriptive one, which means it can be used to predict system acceptance and cannot be used to find out specific system design flaws (Morris & Dillon, 1997).

The study assumes that participants used CPOE system and will provide honest responses to the questions. The participants will answer questions what they believed without consulting others. Respondents will not differ from non-respondents of the survey.

Definitions of Terms

Behavioral Intentions to Use (BI): For the purposes of this study, BI will be measured as the strength of a person's intentions to perform a conscious act such as deciding to accept (or use) a particular system or technology (Ajzen & Fishbein, 1980; Chau & Hu, 2002).

Computerized Physician Order Entry (CPOE): CPOE is a software application and an advanced feature of Electronic Medical Record that initiates care through orders for therapy and procedures. It helps to order tests, medications and treatments; and streamlines the workflow as the information is transferred electronically to the laboratories, pharmacy, etc. (Kini & Savage, 2004).

CPOE Acceptance: According to TAM, CPOE Acceptance is defined as the potential user's predisposition toward personally using the CPOE system and CPOE acceptance leads to CPOE usage (Davis, 1993; Davis et al., 1989; Morris & Dillon, 1997).

CPOE Usage: For the purposes of this study, CPOE Usage will be measured by the self-reported estimation of usage on the job (Davis et al., 1989; Lucas Jr. & Spitler, 2000).

End User: The final or ultimate user of a computer system. The end user is the individual who uses the product after it has been fully developed and marketed. The term “end user” is used to distinguish the person for whom the product was designed from the person, working on a personal computer in a professional capacity, who develops applications, programs, services, or installs the product. The end user may or may not know anything about computers, how they work, or what to do if something goes wrong. In other words, end users are certain to have a different set of assumptions than the developers who created the application (Hyperdictionary, n.d; Webopedia, n.d).

End User Computing: An example of this concept is to use a computer application such as Microsoft Word for processing a word document.

Perceived Ease of Use (PEOU): For the purposes of this study, PEOU will be measured as the degree to which a person believes that using a particular system or technology would be free from effort (Davis, 1989).

Perceived Usefulness (PU): For the purposes of this study, PU will be measured as the degree to which a person believes that using a particular system or technology would improve his or her job performance (Davis, 1989).

Technology Acceptance Model (TAM): A model meant to predict, specifically, the acceptance of information system or technology usage. It posits that usage of information technology or system is determined by beliefs a user holds about, the two central constructs namely Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) of the particular system or technology (Davis, 1989).

Guide to Dissertation

The dissertation consists of five chapters. Chapter 1 includes the introduction with the statement and description of the problem, a brief overview of the theoretical background, description of the proposed model, an overview of independent and dependent variables, the research hypotheses, an outline of research methodology, purpose, significance and objectives of the study, scope, limitations and assumptions of the study, and a list of important definitions of terms. The second chapter provides a review of the Technology Acceptance Model, other relevant information system research studies, and a detailed review of two Technology Acceptance Model studies.

The third chapter describes the methodology including population and sample, instrumentation, reliability and validity of TAM constructs from literature, administration of the survey, and the method of data analysis. Chapters 4 and 5 present the data analysis and discussion, respectively.

CHAPTER II. REVIEW OF THE LITERATURE

General Introduction

The primary objective of the present study was to predict and explain to what extent the Computerized Physician Order Entry system (CPOE) is perceived as *useful* and *easy to use* by physicians, and whether it has been well accepted, adopted, and used by them to practice medicine. In doing so, the researcher also intended to replicate past TAM studies, this time from the physicians' perspective within an organizational context, and to understand the information technology acceptance behavior of physicians in a healthcare organization. The other objectives of this study are to test the various hypotheses based on these relationships between variables, and extend the theoretical validity and empirical applicability of existing TAM literature to healthcare professionals.

The literature review is organized into two sections. The first section reviews literature exploring about a survey of electronic medical records (EMRs) with CPOE capability. The review also discusses the costs, benefits, implementation, and satisfaction of CPOE among physicians and nurses. The second section reviews the literature related to some of the past Technology Acceptance Model research that specifically studied the user acceptance of a given technology or information system in question. In addition, this section discusses the justification in selecting the "Revised Technology Acceptance Model," and how it suits to meet the objectives of the present study. This section will also review the four constructs or variables of TAM, namely perceived ease of use, perceived usefulness, behavioral intention to use, and system usage in detail.

Computerized Physician Order Entry System

As discussed earlier, Computerized Physician Order Entry system (CPOE) is a software application that initiates care through orders for therapy and procedures (Kini & Savage, 2004). Kini and Savage added that CPOE substitutes the multi-copy paper documents for an electronic template that is available for all providers of healthcare. CPOE permits physicians to enter orders into a computer instead of hand-written orders (Kuperman & Gibson, 2003). Kuperman and Gibson further noted that CPOE provides an opportunity to standardize practice, alerts with wrong medications, facilitate patient transfers, and makes the data available for research, management, and quality monitoring.

Rehm and Kraft (2001), in their survey of electronic medical records (EMRs), mentioned that hundreds of products were identified as EMRs, and not all EMRs had full functionality such as computerized physician order entry. Rehm and Kraft further noted that CPOE is an advanced software application of electronic medical record and one of the salient healthcare provider features of EMR. Since the main purpose of the study was to find out the physician acceptance of CPOE by applying the Technology

Acceptance Model (TAM), the ratings of EMRs that have the CPOE capability are briefly discussed in the following section.

Survey Results of EMRs with CPOE Capability

Rehm and Kraft (2001) rated the EMRs with respect to the general design features, healthcare provider features such as physician order entry, and patient functionality features. They considered the following features for the general design, namely data elements, structure and organization of data, accessibility, interfaces and email, training, confidentiality, and accuracy and integrity. Four systems, namely ChartWare, EpicCare, Health Probe, and QD Clinical received five-star ratings for general design features. Features that were of particular interest to physicians were records management, individual case management, and administrative and quality reports that together form the healthcare provider features functionality; and ChartWare, EpicCare, Health Probe, and Logician received five-star ratings from the researchers. EpicCare and Logician are the two systems that received five-star ratings for their patient functionality features such as appointment reminders, access to information, and patient education. The researchers concluded that there is no "one size fits all" EMR; however, they gave overall five-star ratings to three systems namely ChartWare, EpicCare, and Health Probe. To sum it up the EpicCare system that has CPOE capability, also used by the physician population in the present study, not only received five-star ratings for the general design features, healthcare provider features, and patient functionality features but also an overall five-star ratings; and it is equally a good idea to study one of the best CPOE systems available in the market.

Implementation, Costs, and Benefits of CPOE

Implementation of CPOE has been limited in the United States (Kaushal & Bates, 2005). The use of CPOE is not widespread and implementation lags because CPOE is expensive and difficult to implement, and the potential difficulty to convince physicians to use CPOE in their practice (Ash, Stavri, & Kuperman, 2003). The First Consulting Group (FCG) notes that 5% of hospitals in the United States have CPOE, and other hospitals are considering this investment (First Consulting Group, 2003). FCG notes, in their study of costs, benefits and challenges of CPOE, that CPOE is so challenging and costly to implement that implementation requires a high level of organizational commitment in order to reap the potential benefits. FCG conducted a study in six hospitals and all of them used a vendor-based CPOE system. It is not mentioned in their case study as to why FCG has selected the vendor-based systems only for their study as opposed to custom-developed systems, although FCG notes that custom-developed systems were installed in academic medical centers where residents write many of the orders.

The First Consulting Group (2003) estimates that implementing CPOE at a single 500-bed hospital could cost 7.9 million dollars in one-time capital and operating costs and annual ongoing costs of 1.35 million dollars. FCG notes that the above costs are only applicable for a hospital having the basic infrastructure of high-capacity network required for CPOE and with the existing clinical information capability. The other factors that would determine the costs are the size of the organization, the number of sites, and the feasibility of integrating the CPOE system with the existing systems for laboratory, pharmacy and radiology. Kuperman and Gibson (2003) stated that larger hospitals and academic medical centers that require substantial modifications to their existing infrastructure such as newer servers, new clinical workstations, and more training efforts may encounter higher project costs in the tens of million of dollars.

The benefits of CPOE include reduced adverse drug events, standardization of care, and efficient care delivery (First Consulting Group, 2003). There are not many benefits and cost savings studies. According to FCG, the benefits stated in the published literature are what are believed to achievable by the healthcare organizations rather than what is actually achieved. Of the six sites First Consulting Group (FCG) studied, only one site conducted a formal study of the impact of CPOE and found significant process improvement, elimination of medication transcription errors, and a small reduction in length of the stay at the hospital. However, this site, FCG noted, did not find any significant impact on overall costs. Kuperman and Gibson (2003), however, observed that a few studies have examined the effect of CPOE on overall hospital costs and length of stay. In one of those studies, Kuperman and Gibson noted that the cost of the hospital stay was reduced to $25,325 from $35,283, and the length of stay was reduced to 10 days from 12.9 days.

CPOE Adoption in the United States

Ash et al. (2004) randomly selected 924 hospitals for their study of inpatient CPOE availability in U.S. hospitals and 626 hospitals participated. The researchers noted that complete CPOE was available to physicians only in 60 hospitals, and in 41 hospitals CPOE was only partially available. The use of CPOE is frequently required in hospitals that have CPOE. Ash et al. noted that there are approximately 6000 hospitals in the United States, and estimated that only 9.6% of hospitals have CPOE completely available. One could very well argue that adoption of CPOE is still in its infancy in the United States, and efforts should be undertaken to make CPOE available to physicians at most of the hospitals considering the projected benefits and ultimate cost savings. The projected benefits and cost savings may not be an incentive for practicing physicians since switching to CPOE from paper-based medical record involves more time spent at work (Doolan & Bates, 2002). Doolan and Bates have identified four important barriers to adoption of CPOE: physicians' work practices, current level of technology, status of commercial systems, and lack of financial incentives among other barriers. In addition to physicians' lack of financial incentives, Doolan and Bates interestingly observed that the hospitals could also be reluctant to have CPOE available to physicians since implementing CPOE in hospitals might have a negative impact on its finances due to reduced test ordering and shorter lengths of stay in the hospital in a fee-for-service environment.

CPOE Satisfaction Studies

There are no studies carried out on CPOE adoption per se, but three studies have focused on satisfaction with CPOE, and one on successful implementation of CPOE (Kuperman & Gibson, 2003). Lee, Teich, Spurr, and Bates (1996) conducted a study among physicians and nurses in an academic medical center to find out the satisfaction with CPOE system. Overall satisfaction rate was high with a mean of 5.07 on a seven-point scale. The physicians had a satisfaction level of 5.26, and nurses had a satisfaction level of 4.84. The users from medical services were more satisfied than the users from surgical services; the mean for medical services is 5.55 and surgical services 4.55, respectively. The ratings for all groups were above the midpoint. Productivity, ease of use, reliability, patient care quality, and speed contributed to their satisfaction. (Lee, Teich, Spurr, & Bates, 1996).

Weiner, Gress, Thiemann, Jenckes, Reel, Mandell, et al. (1999) studied a modified commercial CPOE application among physicians and nurses in an academic medical center to find out their satisfaction with CPOE. The study focused on time spent on patients, resource utilization, errors with orders, and overall quality of care. The researchers found that 29% to 34% of physicians felt the quality of the CPOE was good, and 34% to 42% physicians reported high satisfaction with CPOE (Weiner et al., 1999).

The researchers added that 61% of physicians and 41% of fellows indicated an increase in order errors, and 69% of nurses indicated either no change or a decrease in order errors. To be specific, physicians and nurses had different views about the effects of CPOE on patient care; most nurses saw beneficial effects, and physicians saw negative effects.

Murf and Kannry (2001) studied physician satisfaction with the user interface of two CPOE applications among house officers in two different hospitals; the researchers found the satisfaction level of 3.67 out of 9 in a commercial in-patient CPOE system, and 7.21 out of 9 for the Veteran Administration's CPOE. The user satisfaction differed significantly between two order entry systems and the researchers cautioned that not all order entry systems are equally usable. The ability to perform tasks in a straightforward way correlated strongly with the satisfaction (Murff & Kannry, 2001). This finding suggests that physicians want to perform the given tasks in an easy manner without any difficulty in using the system. Similarly, in the present TAM study of physician acceptance of CPOE, one could expect the construct perceived ease of use to be positively correlated with the CPOE usage provided the system is easy to use and free from effort.

In an article that discussed the successful implementation of CPOE in the Ohio State University Health System, the researchers stressed the importance of continuous executive support, establishment of a physician consultant team, and ongoing support for problem solving (Ahmad et al., 2002). The researchers further added that obstacles to implementation were more organizational than technical. The researchers noted that providing a friendly user interface for CPOE would increase the usability, and allowing only electronic physician order entry would decrease the possibility of physicians reverting to paper order entry. The authors suggested that for the success of implementation and for physicians to accept CPOE, three main criteria are necessary: the availability of specialty–specific orders, the engagement of physician leadership, and large-scale system implementation.

Poon, Blumenthal, Jaggi, Honour, Bates, and Kaushal (2004) interviewed senior management at twenty six hospitals, and observed that strong leadership and high quality of technology are critical for overcoming barriers to successful implementation and adoption of CPOE in United States hospitals. One could argue that the usefulness and ease of use of use of the CPOE are two important hallmarks of the quality of the CPOE in question. Measuring the two main constructs of TAM, namely perceived usefulness and perceived ease of use of CPOE, would shed some light on the quality of CPOE and how it influences CPOE adoption.

There are no studies conducted to date on CPOE adoption by applying TAM, although Seeman, Gibson, and Rosenthal (2005) conducted a study to explain physician acceptance of CPOE based on their model of the taxonomy of work values and the theory of planned behavior. Their study was longitudinal, with the researchers collecting data through proven qualitative techniques such as semi-structured interviews, direct observations, field notes, and documentation/record analysis. The researchers found empirical support for the theories that supported their model (Seeman, Gibson, & Rosenthal, 2005).

Review of the Technology Acceptance Model

As discussed in Chapter 1, TAM is a powerful model to study the determinants of user acceptance of end-user computing (Davis et al., 1989). TAM is strongly grounded in existing psychological theory and found to be robust. The value and power of TAM lies in its ease of use and its cost-effectiveness (Morris & Dillon, 1997). Morris and Dillon added that the majority of Human-Computer Interaction (HCI) researchers have focused more on a *system's usability,* while the information system-proven TAM that accounts for *system usefulness* variable was frequently overlooked. System usefulness is defined as the extent to which the system is able to help the user perform on the job. TAM offers HCI professionals a theoretically grounded approach to the study of information technology acceptance by coupling with the usability evaluations. Together, the system's usability and system usefulness have a strong bearing on user acceptance of the system studied. Studying physician acceptance of CPOE by applying TAM provides a base to assess both the CPOE's usability and CPOE usefulness.

Technology Acceptance Model (TAM) Origins

Many studies have been conducted to identify the factors that contribute to information system (IS) success and different researchers have addressed different aspects of success of IS (DeLone & McLean, 1992). DeLone and McLean added that the above approach not only made comparisons among studies difficult but also failed to define a concrete dependable variable to measure the information system success. They reviewed 180 empirical studies and discussed the implications for future research. The researchers suggested that the dependent variable is the most important issue in IS research, and defining one such dependent variable was elusive. They further argued that measuring various independent variables that different researchers have used did not auger well to IS research without a well-defined dependent variable that accurately measures the outcome--the IS success.

Davis (1989) observed that non-validated measures were routinely used in IS research even in big vendor organizations such as IBM, Xerox, and Digital Equipment Corporation. Davis further added that subjective measures were used widely in research with minimal attention paid to the quality of the measures used or how well they correlated with the usage behavior, and thus the decision makers were making important business decisions based on misinformation about a system’s acceptability to users.

Growing Importance of TAM Studies

Legris, Ingham and Collerette (2003) conducted a meta-analysis and critically reviewed selected important TAM studies. They observed that, historically, IS research was mainly conducted to discover the factors that facilitated IS use and resulted in a long list of items or factors that were of minimal practical value. However, since the mid-1980s, IS research has focused more on the development and testing of models that could help to predict system use (Chau, 1996; Cheney, Mann, & Amoroso, 1986). It also became a necessity to group different factors into a model that would analyze and predict IS use (Legris et al., 2003).

In 1986, Fred Davis introduced TAM, which was specifically tailored to predict and explain the user acceptance of information systems (Davis et al., 1989). TAM is an adaptation of the Theory of Reasoned Action (TRA), developed by Fishbein and Ajzen (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). The basic premise of TRA is that people will choose and adopt a specific behavior if they perceive that it will lead to positive outcomes (Compeau & Higgins, 1995). TRA is an intention-based model and has been successful in predicting and explaining behavior across many domains. TRA is very general in nature, and designed to explain any human behavior (Davis et al., 1989). TAM, on the other hand, is specifically intended to explain computer usage behavior (Davis, 1993). In TAM, system usage intentions and behavior are a function of perceived Usefulness (PU) and perceived Ease of Use (PEOU) of the given information system

(Davis & Venkatesh, 1996). TAM considers that perceived ease of use (PEOU) and perceived usefulness (PU) are the two important user acceptance factors and fundamental determinants of system use (Davis, 1989; Gould, Boies, & Lewis, 1991; Hill & Smith, 1987).

PEOU and PU as determinants of user behavior are indicated in many diverse research studies and have strong theoretical foundations. The theoretical foundations include the perceived user-performance contingency in Robey's model (Robey, 1979), expectancy-theoretic model (Vroom, 1964), self-efficacy theory (Bandura, 1982), cost-benefit paradigm (Beach & Mitchell, 1978; Johnson & Payne, 1985), adoptions of innovations (Tornatzky & Klein, 1982), channel disposition model (Swanson, 1982), evaluation of information reports, and non-management information system studies (Davis, 1989). The discussion of the above theoretical foundations in detail is beyond the scope of the proposed study, as there is no intention to investigate the antecedents of PEOU and PU in this study.

TAM further provides a rationale for explaining the impact of external variables on users' intentions and the probability of system usage through the mediating roles of PU and PEOU. The probability of system use is considered an indicator for system success (Davis, 1993; Davis et al., 1989). Davis and Venkatesh (1996) stated that TAM "was designed to understand the causal chain linking the external variables to its user acceptance and actual use in a workplace" (p. 20). Davis theorized that external variables such as objective design features, training, computer self-efficacy, user involvement in design, and the nature of implementing process influence behavioral intentions to use, and finally usage, through the mediating influence on perceived usefulness and perceived ease of use (Davis & Venkatesh, 1996). Davis, Bagozzi, and Warshaw (1989), while finding support for TAM, noted the predictive power of perceived usefulness in explaining more than half of the variance in intention to use the system. Perceived usefulness was considered more influential than perceived ease of use in determining the usage. Perceived ease of use, in addition to its direct influence on usage, mediated its influence through perceived usefulness on usage. In essence, TAM postulates that many external variables intervene indirectly by influencing PEOU and PU in predicting the acceptance and usage of an information system.

Legris, Ingham, and Collerette (2003) noted that there was no clear pattern of the choice of external variables studied in various TAM studies. In 13 of the 22 TAM studies in their analysis, they found 37 different external variables were used. As of January 2000, according to the Institute for Scientific Information's Social Science Citation Index, the two journal articles that introduced TAM, namely Davis (1989) and Davis et al. (1989), were cited in 424 journal articles (Venkatesh & Davis, 2000). Money and Tuner (2004) stated that information technology researchers are paying even more heavy attention to TAM now. In such a scenario, it is reasonable to assume that the number of external variables having been studied so far to facilitate IS use and acceptance would be in hundreds. Legris, Ingham, and Collerette (2003) observed that in the other nine studies there were no specific external variables used since TAM posits (Bajaj & Nidumolou, 1998; Davis, 1989; Morris & Dillon, 1997; Szajna, 1996) that the effects of all external variables are mediated through the two main constructs, perceived usefulness and perceived ease of use. Studying these two constructs is important according to technology acceptance model (Davis, 1989; Davis et al., 1989). It is equally understandable not to have used any specific external variables in these nine studies, as the emphasis of TAM was more on the user acceptance and usage of a technology or information system rather than what best predicts the acceptance technology or information system (Davis & Venkatesh, 1996; Money & Turner, 2004). In summary, TAM was specifically designed to study the effects of all external variables on the mediating variables or constructs such as perceived usefulness, perceived ease of use, behavioral intentions to use, and ultimately on the actual usage and acceptance of the information system.

In addition to the existing technology acceptance models, the principal TAM researchers have come out with two other models, namely Technology Acceptance Model 2 and Unified Theory of Acceptance and Use of Technology model, integrating elements from several theoretical models. Both models added new variables to further develop TAM, and tested in longitudinal studies (Venkatesh & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003). Discussion of these two models and the respective external variables are beyond the scope of this study, as the main objective here is to find out the physician adoption of CPOE by measuring the collective impact of external variables on the constructs, perceived use of use of CPOE and perceived usefulness of CPOE, and how those effects are mediated through behavioral intention to use CPOE on CPOE usage.

Rationale for Model Selection

With the introduction of two more technology acceptance models, more external variables would be tested now and how they impact the user acceptance of the studied technology. Moreover, when TAM is studied in an organizational setting, there may be many uncontrollable environmental variables, in addition to controllable variables, that would influence the acceptance of a given technology or information system implemented. Under these circumstances, it is questionable to study many different external variables that may not help the IS research (DeLone & McLean, 1992), especially without a clear pattern of the choice of external variables (Legris et al., 2003). Further, studying more external variables could be seen as a distraction from the original intent of formulating the technology acceptance model, which is to study the user acceptance of a technology or information system and the user behavior rather than what external variables best predict the user acceptance of a given technology or information system. Moreover, in the present study, there is no intention to investigate antecedents of perceived usefulness and perceived ease of use, and hence no external variables are studied. This approach, to apply the revised TAM for the proposed study, is in line and consistent with other empirical research that focused on perceived usefulness and perceived ease of use, rather on the external variables, to study the user acceptance of a technology in question (Davis, 1989; Davis, 1993; Davis et al., 1989; Davis & Venkatesh, 1996; Money & Turner, 2004; Morris & Dillon, 1997; Venkatesh & Davis, 2000).

The main objective of the present study is to predict and explain to what extent the CPOE system is perceived as *useful* and *easy to use*, without the intent to study what external variables best predict user acceptance of CPOE in an organization. The selection of revised TAM for this study is further justified because the main beliefs, perceived usefulness and perceived ease of use, hypothesized to be fundamental determinants of user acceptance behaviors, are retained in this revised TAM, and the hypotheses are developed accordingly to meet the objectives of this study (Davis, 1989; Davis et al., 1989; Morris & Dillon, 1997; Venkatesh & Davis, 2000).

Further, the revised TAM is still widely used by researchers to meet the objectives of their studies. For example, Money and Turner (2004) applied the revised TAM to address two questions: One was to study the user acceptance and usage of a knowledge management information system implemented to support knowledge management objectives in an organization. Second was to find out whether the previous Technology Acceptance Model user acceptance research is still valid now to investigate the user acceptance of a knowledge management information system. Money and Turner added that their findings were significant in their study and in agreement with past research findings. They also suggested that the previous TAM-related research may serve as a foundation and the revised TAM was successfully applied to study the knowledge management system user acceptance in an organization.

In another study, Leong and Huang (2002) examined whether the earlier results of TAM studies are still valid now to predict system usage because of rapid advances in information technology. They have indicated that their results suggested positive and significant relationships between perceived usefulness and perceived ease of use to system usage; and opined that TAM was supported substantially well. The selection of revised TAM is essential to meet the purpose and objectives of the present study. The revised TAM is discussed in Chapter 1.

Revised Technology Acceptance Model's Constructs or Variables

This section reviews the four constructs or variables of "Revised TAM" used in this study, namely perceived ease of use, perceived usefulness, behavioral intention to use, behavioral intention to use, and system usage.

Perceived Ease of Use (PEOU)

Perceived Ease of Use (PEOU) refers to the degree to which the user expects the target system, CPOE in the present study, is free of effort (Davis et al., 1989). TAM posits that PEOU has a significant positive influence on the behavioral intention to use. Davis et al. suggested that the easier the system is to interact with, the greater the user's ability will be to carry out the sequences of behavior needed to use the system. If all other factors are equal or constant, an application considered to be *easy to use* is more likely to be accepted by the users (Davis, 1989). In addition, improvements in PEOU could be responsible for increased performance as the effort or time saved due to improvements in PEOU could be utilized to accomplish more work for the given amount of time. Many system features such as menus, icons, and a mouse could enhance usability of the target system, and the impact of system features on PEOU have been well documented (Davis et al., 1989; Davis, Bagozzi, & Warshaw, 1992). Other factors such as training, documentation, and consultant support may also influence PEOU. The effect of training interventions have been shown to be mediated by PEOU (Venkatesh, 1999). Research has also shown that PEOU plays an important role on adoption of innovations (Chau, 1996).

Perceived Usefulness (PU)

TAM posits that PU also has a significant positive influence on the behavioral intention to use, and is another main construct of TAM. Davis (1989) posited that people tend to use or not use a particular computer system or application to the extent they believe that the particular system or application will help them to perform their job *better* and enhance their job performance. Davis noted that this explanation of perceived usefulness comes "from the definition of the word useful: 'capable of being used advantageously.'" (p. 320). Therefore, a system that scores high in perceived usefulness will have a positive user-performance relationship (Davis, 1989; Davis et al., 1989). TAM researchers further noted that even if the users believe that the system or application is very difficult to use, they would still use the system or application if the benefits of using the system outweigh the effort needed to use the system. In addition, PEOU would also have an impact on PU to *the extent* that increased ease of use contributes to improved *job performance*. Thus TAM posits that PU and PEOU are distinct but related constructs, and there is empirical evidence from factor analyses that PU and PEOU are distinct constructs (Davis et al., 1989; Morris & Dillon, 1997).

Davis et al. (1989) added that modeling the constructs as distinct enables the researchers to extend the model and trace the effect of external variables on these two constructs PU and PEOU. The researchers further noted that, from a practical standpoint, one could formulate strategies for increasing the user acceptance of a computer system or application. For example, a researcher could focus on increasing PEOU by providing a better user-interface or better training and by increasing the accuracy or amount of information. In addition, increasing objective-design characteristics can have a direct influence on PU in addition to indirect effects via PEOU. Therefore, PEOU and PU are first dependent variables with respect to external variables. Then PU is also a dependent variable to PEOU. PEOU and PU are, in turn, independent variables with respect to the next dependent variable, Behavioral Intention to use (BI).

Behavioral Intention to Use (BI) and CPOE Usage (USAGE)

TAM posits that the behavioral intention to use is the single best predictor of actual system usage and well supported by past TAM research (Davis & Venkatesh, 1996; Morris & Dillon, 1997). The behavioral intention to use a system is determined by the two specific beliefs, perceived ease of use and perceived usefulness. PEOU and PU, with relative weights, jointly influence BI; and BI is a mediating or intermediate variable that mediates the effects of PEOU and PU on CPOE usage, the surrogate for CPOE adoption, the dependent variable of this study. Past TAM research has shown that the construct behavioral intention to use fully mediated the effects of perceived usefulness and ease of use on usage behavior (Davis & Venkatesh, 1996; Venkatesh & Davis, 2000). The constructs or variables BI and Usage are discussed in detail in the following section.

The Quest for the Dependent Variable in TAM Studies

The quest for the dependent variable exists even among the TAM studies because different researchers use different dependent variables rationalizing their choices. Some researchers have used BI as their only dependent variable (Amoako-Gyampah & Salam, 2004; Brown et al., 2002; Chau & Hu, 2002; Hu et al., 1999), deleting the system usage variable to predict and explain technology acceptance. Certain other researchers have preferred to use only the system usage variable as their dependent variable (Bajaj & Nidumolou, 1998; Igbaria et al., 1997; Karahanna & Straub, 1999; Lederer, Maupin, Sena, & Zhuang, 2000; Leong & Hunag, 2002), deleting the BI variable to predict and explain technology acceptance. On the contrary, many researchers still prefer to use both the variables, behavioral intentions to use and system usage, in their research model in several cross-sectional, longitudinal, and post-implementation of technology acceptance studies to predict technology or information system acceptance and explain user behavior (Davis & Venkatesh, 1996; Money & Turner, 2004; Szajna, 1996; Taylor & Todd, 1995a, 1995b; Venkatesh, 1999; Venkatesh & Davis, 2000). Regardless of the preference, behavioral intentions to use and system usage are being used as dependent variables in TAM studies, either independently or together, as surrogates to predict and explain technology or information system acceptance.

Lucas and Spitler (2000) studied the technology acceptance and usage of broker workstations by applying the technology acceptance model in an institutional brokerage group of a major stock brokerage firm. Data were collected in the fall of 1993 (time 1) within six months of installation of a new workstation and again in the fall of 1995 (time 2) for the brokers in that group to test their research model. While Lucas and Spitler studied the system usage variable on both time periods, they chose not to study the behavioral intentions to use the workstation variable in the time 2 study because they were of the view that the workstation had been used for a long time, and the behavioral intention measures would not accurately depict the intentions to use the system. However, many researchers continue to study behavioral intentions to use with the usage variable even in longitudinal and post-implementation TAM studies, as they believe that behavioral intention measures are still valid in explaining the technology or information system acceptance and user behavior (Davis & Venkatesh, 1996; Money & Turner, 2004; Szajna, 1996; Taylor & Todd, 1995a, 1995b; Venkatesh, 1999; Venkatesh & Davis, 2000). Further, BI is an integral part of the technology acceptance model (Davis, 1989; Davis et al., 1989), and therefore continues to be used.

Szajna (1996) observed that intentions to predict usage were stronger in the post-implementation model suggesting the acquired additional information about the workstation by the subjects as the reasons. Szajna also cited similar results with the 1989 study of Davis et al. Further, Szajna claims that the experience gained over the period of time could be also another factor for a stronger association of intentions to use with the usage behavior in the post-implementation model. Szajna further added that the above observation is consistent with Ajzen (1987), who claims that intention-behavior link would be stronger with more experience and information gained from experience has the potential to change future intentions. Based on the above findings the behavioral intention to use variable will also be used in this study as a mediating variable in the causal chain linking the variables perceived ease of use and perceived usefulness to CPOE usage.

TAM – A Robust and Powerful Model

The Technology Acceptance Model examines the impact of constructs perceived usefulness and perceived ease of use, mediating the collective influence of external variables, on the behavioral intention to use and system use (Legris et al., 2003). In most of the studies, researchers have found that TAM consistently explains a substantial proportion of the variance, typically around 40%, in usage intentions and behavior (Sun & Zhang, 2004; Venkatesh & Davis, 2000). A question could arise as to how, by explaining only around 40% of the variance in dependent variables, although consistently, a model such as TAM can be called a robust and powerful model.

Rosenthal (1990) observed that analyses of variance need caution, as one should not judge the outcome of the study with the percentage of variance of the dependent variable alone by explaining with an aspirin study in preventing heart attacks conducted among physicians as subjects. In the study of effects of aspirin among 22,000 physicians, divided equally in a randomized double-blind experiment, 189 physicians who were on a placebo suffered heart attacks, and 104 physicians who were on aspirin suffered heart attacks (Rosenthal, 1990). Rosenthal added that the Steering Committee of the Physician's Health Study Research Group prematurely stopped this study due to the obvious benefits of aspirin in prevention of heart attacks and the lack of ethics in continuing to give half of the physician research subjects a placebo. The R^2 of the study was .0011 and R was .034. Rosenthal added that R is the effect size or the magnitude of the effect on the outcome. In other words, the risk of a heart attack was cut by .034% with aspirin intake by physicians, and it explained only .11% of the variance in reducing heart attacks.

Rosenthal (1990) opined that behavioral researchers, typically, are not used to thinking of *Rs* of .034 as reflecting effect sizes of practical importance**.** Instead, he wanted us to think any *R* of .034 as reflecting a 3 to 4% decrease in heart attacks, especially if we could count ourselves among the 3 to 4 per 100 who manage to survive by taking aspirin. Further, if the researcher administered aspirin doses in increments of 10 mg to X number of groups, the proportion of this .11% variance will be divided among the X levels. The X number of groups will further share the variance of .11%, and yet one group could be more significant than the rest. The importance of the study lies in the fact that aspirin intake cuts the risk of heart attacks and not on the amount of variance of aspirin on the outcome.

Similarly, in TAM, although around 40% of variance in intentions behavior and usage is explained typically (Leong & Hunag, 2002; Lucas Jr. & Spitler, 2000), there may be hundreds of known and unknown variables or factors that could be responsible for the remaining 60% of variance, and it is not an ordinary task to identify and account for 100% of the variance. As stated before, is it advisable to study many different external variables that may not help the IS research (DeLone & McLean, 1992), and without a clear pattern of the choice of external variables (Legris et al., 2003) as carried out in many TAM studies? Therefore, explaining the 40% of variance consistently with a simple model such as TAM is of great value to predict and study technology acceptance and user behavior.

While the *R* value indicates the correlation between the dependent variable and the independent variables, the R^2 value identifies the portion of the variance accounted by the independent variables (George & Mallery, 2000). With respect to TAM, the total R^2 value on system usage refers to the fraction of variance explained in this model by each of the variables, namely perceived usefulness, perceived ease of use, and behavioral intentions to use. In the following section, two selected relevant "Revised Technological Acceptance Model" studies are reviewed.

Review of Two Relevant Revised TAM Studies

Leong and Huang (2002) applied the technology acceptance model to predict the Microsoft (MS) Access usage among the employees in an organization in the United States. They used system usage as the dependent variable with the perceived usefulness and perceived ease of use as independent variables. In addition, they introduced two other external variables, management support and system quality, as additional independent variables.

The population for this study was from a Pacific Northwest information technology company's full-time employees. One hundred and eighteen usable surveys were returned out of the two hundred and fifty employees who received the survey.

The instruments used in this study were from past research and had acceptable levels of reliability and validity (Straub et al., 1995; Szajna, 1996). However, the instruments were modified for this study by substituting with MS Access, the application software that was studied. The overall weighted reliability of the survey instruments measured by Cronbach Alpha values was .851. The authors chose multiple regression analysis because the contribution of each independent variable could be identified to the outcome, system usage, the dependent variable of this study.

The R of this study was .657 and R^2 was .431, suggesting that 43% of variance in MS Access usage was explained by the four independent variables: perceived usefulness, perceived ease of use, management support, and system quality. Of the entire four null hypotheses, two were rejected and two were not, as given below. The two variables, perceived usefulness and perceived ease of use, were significantly related to MS Access usage while the other two, management support and system quality, were not significantly related to MS Access usage.

Perceived usefulness of MS Access is significantly related to MS Access usage, as indicated by the standardized regression coefficient (Beta) of .544 and the significance level is .000 ($p<.05$) for perceived usefulness. This was consistent with the past research (Davis et al., 1989; Igbaria et al., 1997; Straub et al., 1995; Szajna, 1996) that had similar results indicating that perceived usefulness was positively related to usage.

B value (absolute value) or unstandardized B coefficient helps to identify each independent variable's influence on the dependent variable, however, each independent variable's influence on the dependent variable cannot be compared easily because different scales and metrics could have been used in the study (George & Mallery, 2000). George and Mallery added that in order to alleviate this problem and to allow direct comparison of relationships between variables statisticians have come out with a standardized score called Beta (β). β score ranges between $\pm$ 1.0 and is a partial correlation between two variables after the influence of other variables have been controlled.

Perceived ease of use of MS Access was significantly related to MS Access usage, as indicated by the standardized regression coefficient (Beta) of .255 and the p-value of .004, ($p<.05$) for perceived ease of use. This was also consistent with past research (Davis et al., 1989; Mathieson, 1991; Straub et al., 1995; Szajna, 1996) indicating that perceived ease of use was positively related to usage.

The other two independent (external) variables, system quality and management support, were not significantly related to the MS Access usage, as indicated by the standardized regression coefficient (Beta) of -.035 and the significance level of .730 ($p>.05$), and standardized regression coefficient (Beta) of -.052 and the significance level of .505 ($p>.05$), respectively. In summary, the bulk of the 43% variance in MS Access usage was contributed by the two belief constructs of TAM, perceived usefulness and perceived ease of use. The results of this study indicated that TAM was well supported and confirmed the fundamental premise of TAM that perceived usefulness and perceived ease of use are indeed the determinants of user behavior (Davis, 1989; Davis et al., 1989). The authors, Leong and Huang (2002), concluded that the past TAM research and results were still valid in spite of recent advances in technology and systems that affect system usage.

In another study, Money and Turner (2004) applied the technology acceptance model to study the user acceptance of a knowledge management system. The knowledge management system was described as an information system that effectively managed the intellectual resources and obtained the greatest value for organizations with the knowledge resources available (Grover & Davenport, 2001; Marwick, 2001). Recent advances in information technology are certainly one of the factors for the increased interest and for enterprise knowledge management initiatives (Alavi & Leidner, 2001; Grover & Davenport, 2001). Money and Turner's study is of interest since CPOE is also a clinical knowledge management system (Rehm & Kraft, 2001). Moreover, the present study of CPOE acceptance will apply the revised technology acceptance model, as envisaged by Money and Turner in their study, with all the four constructs, namely perceived usefulness, perceived ease of use, behavioral intentions to use, system usage, and with no external variables included in the model.

Money and Turner (2004) used a fifteen-item survey to study the four constructs, and the measurement scales were drawn from the past technology acceptance research. These scales have been consistently used and well validated with excellent psychometric properties (Davis & Venkatesh, 1996; Davis & Warshaw, 1992; Venkatesh & Davis, 2000). The overall weighted reliability of all the instruments used for this survey was .944. This far exceeds the preferred level of Cronbach Alpha values of .60 or greater, recommended for behavioral studies (Morris & Dillon, 1997).

The population of the study conducted by Money and Turner of 2004 consisted of employees in an organization from two major Northeastern U. S. metropolitan areas with system access. Fifty one employees responded with the surveys of which only thirty five were usable. From their multiple regression analysis, Money and Turner observed significant positive relationships between perceived usefulness, perceived ease of use and behavioral intentions to use; and between perceived usefulness, perceived ease of use and system usage. The R^2 value of .472 in behavioral intention to use was accounted by the combined effect of perceived usefulness and perceived ease of use, which translates to 47% of variance in behavioral intention to use the system explained by perceived usefulness and perceived ease of use. This was consistent with past TAM research. The R^2 value of system usage is .344; 34% of the variance explained by the combined effect of perceived usefulness and perceived ease of system usage, and these results were consistent with past TAM research, although slightly lower than the normal 40% of usage variance observed in most of TAM research. The results of this study affirmed that the technology acceptance model could be successfully applied to the new domain of knowledge management system.

The review of these two studies confirms that previous technology acceptance model user acceptance research serves as a foundation and basis to study the user acceptance and usage of CPOE by practicing physicians. Further, the present study, while replicating past TAM research, this time from the physicians' perspective within an organizational context, will also help to understand the information technology acceptance behavior of physicians in healthcare organizations. In addition, testing the various hypotheses based on the relationships between variables will help to extend the theoretical validity and empirical applicability of existing TAM literature to healthcare professionals.

CHAPTER III. METHODOLOGY

This chapter provides a detailed review of the research methodology used in the study. The main purpose of this study was to apply TAM in order predict and to explain the extent to which the Computerized Physician Order Entry system (CPOE) is perceived as *useful* and *easy to use* by physicians in a healthcare organization, and whether it has been accepted, adopted, and used by them in their practice. In doing so, the researcher intended to apply TAM from the physicians' perspective within an organizational context. The other objectives of this study were to examine and explain the perception-behavioral intentions-behavior relationship within TAM, and test the six hypotheses developed for these relationships. This will help researchers and practitioners to understand the information technology acceptance behavior of physicians in a healthcare organization. Efforts were made to keep the research methodology identical to that developed by Davis et al. (1989) to maintain the continuity of TAM research studies. This chapter includes the following sections: population and sample, research design, instrumentation, administration, validity and reliability, and data analysis.

Population and Sample

The population for this study was physicians from Buffalo Hospital, one of the hospitals in the Allina Health System (Allina), a non-profit healthcare organization in Minnesota. Allina has plans to fully implement EpicCare, a conventional electronic medical record (EMR) that has CPOE capability, in all its hospitals and affiliated clinics by 2008. I, along with two professors, my advisors, at the Health Informatics & NLM Training program, University of Minnesota, had a meeting with Allina management, and they had assured us access to conduct this research. Subsequently, in November 2005 the Allina management gave written permission to conduct the study. The researcher also had several meetings with a senior manger who is overseeing the implementation of CPOE and with the manager in charge of CPOE training, Allina Hospitals and Clinics, Minnesota and based on their feedback the following information is provided.

The 100 physicians from various specialties, who have had training on the CPOE system, working and/or having admitting privileges at the Buffalo Hospital, Minnesota, constitute the whole population of this study, and all are available to participate. The population of 100 physicians consists of 77 men and 23 women. The breakdown of physicians with respect to each specialty is not a matter of interest in this study as the purpose of this study was to find the physicians' adoption of CPOE as a whole and not with respect to each specialty. Moreover, no demographic information was requested from the participants in the survey.

The first phase of CPOE implementation, from paper to CPOE, was launched overnight on September 1, 2004 at the Buffalo hospital of Allina health system; other hospitals of Allina health system are following suit in phases. The physicians were given training on the CPOE system shortly before its implementation. The training team called it *just in time training*. First, the physicians had to complete an E-learning module that outlined the objectives of CPOE and the basic information they need to know about CPOE. The module required an average of two hours to complete. Prior to that, physicians were given four months advance notice about the intent to launch CPOE at the Buffalo Hospital, and they were also provided with hardcopies of a brief introduction and the basics of CPOE system. After completion of the E-learning module, they were trained on three modules of EpicCare for approximately five hours for each module. Each module training was spaced with a week's time apart. The three modules were Chart and Review, Clinical Documentation, and finally the CPOE. Physicians were expected to score at least 80% on the assessments that followed each training module, and those who received less than 80% had to undergo remedial training.

There were some initial teething problems after the launch of CPOE, and those issues were addressed on an ongoing basis, enabling the physicians to continue to use CPOE in their practice. After the implementation of CPOE, a group of technical help personnel known as Red-Vest was deployed to assist the physicians if they had any technical problems with use of CPOE. According to both Allina managers, physicians were comfortable and coped well with the training provided as well as the use of CPOE in their practice. All physicians at Buffalo hospital enter the orders on CPOE system by themselves. They do not delegate that power to other personnel. There are some orders, less than 10%, that the physicians still order on paper.

The list of practicing physicians at Buffalo hospital, who have had training on CPOE, was provided by the Allina management. As the population itself is very small, efforts were taken to receive as many responses as possible from physicians. Issues related to response rate are discussed later. The inclusion criterion for the subjects was limited to practicing physicians who have received CPOE training and are currently using the system. There were no exclusion criteria. Since the population size is small, content experts who participated in the pilot test were not from this pool of physicians. Including them twice in the study may induce retest bias, as they would be familiar with the content of test items.

Instrumentation

Overview and Discussion of TAM Instrument

The survey administered in the present study measured the four constructs of TAM, namely Ease of Use (PEOU), Usefulness (PU), Behavioral Intentions (BI), and CPOE Usage. The three constructs or variables PEOU, PU, and BI have been consistently tested and validated using TAM scales in many studies to study a wide range of technologies (Amoako-Gyampah & Salam, 2004; Brown et al., 2002; Chau & Hu, 2002; Davis et al., 1992; Hu et al., 1999; Lucas Jr. & Spitler, 2000; Mathieson, 1991; Money & Turner, 2004; Morris & Dillon, 1997; Szajna, 1996; Taylor & Todd, 1995a, 1995b; Venkatesh, 1999; Venkatesh & Davis, 2000; Venkatesh, Speier, & Morris, 2002). The other construct or variable, system usage, is normally measured either by an objective measurement of time logged or self-reported usage measures. Self-reported system use measures are accepted in information system research to operationalize system usage, when objective metrics are unavailable or difficult to obtain from the participants (Davis et al., 1989). Straub, Limayem, and Karahanna-Evaristo (1995) observed that there is insufficient literature to guide on the appropriate measures to study usage that could vary according to circumstances. The two forms of system usage applied in TAM studies are subjective, self-reported measures (Davis et al., 1989; Davis & Venkatesh, 1996), and objective, computer recorded and generated measures (Ginzberg, 1981; Robey, 1979). Computer-generated data are large in volume and processing them requires a larger budget and time, and researchers are faced with ethical issues related to privacy as well, especially when attempts are made to access full text of records of users (Straub & Collins, 1990). With the Health Insurance Portability and Accountability Act of 1996 in place, gathering data from the physicians and their usage about CPOE involving patients' treatment and management may be difficult to achieve. Computer-generated log-in records, even if obtained, may not be accurate in this research scenario, and serve little purpose as nothing prevents a physician from continuing to log on to the system after reporting usage, and get involved with patient consulting. Computer-generated data typically gather longitudinal data, and because the present study is a cross-sectional one, self-reported measures may be more appropriate. Lucas and Spitler (2000) also justified using self-reported usage measures in their cross-sectional study as observing usage and monitoring the usage accurately were considered very difficult. The present study simply adapts the two-item system usage scales, originally taken from Davis et al. and applied later by Lucas and Spitler (2000) in their extended technology acceptance model to study the stockbrokers' acceptance of broker workstation and implementation success.

Researchers have found that measuring neutral activities or behavior such as computer use by subjective and objective measures is highly consistent (Ajzen, 1988). Ajzen added that a behavior or activity is neutral when it is neither socially desirable nor undesirable; and self-reports may not be biased as in the case of socially desirable or undesirable behavior. Computer usage is a neutral behavior. Therefore, for the present study, self-reported measures were used to test the variable usage consistent with other TAM researchers, who have used self-reported system usage measures in their studies (Adams et al., 1992; Davis, 1989; Davis, 1993; Igbaria et al., 1997; Lucas Jr. & Spitler, 2000; Mathieson, 1991; Money & Turner, 2004; Morris & Dillon, 1997; Venkatesh & Davis, 2000).

In conclusion, all the four constructs of the present study were examined using previously developed and well validated scales of TAM instrument. The actual development of the survey instrument for the four constructs will be discussed in detail in the *TAM Instrument Development* section of this chapter. According to Davis et al. (1989) system acceptance leads to system usage, and several researchers mentioned above have successfully studied the system usage measures in their studies to predict and explain technology acceptance. In other words, technology acceptance leads to successful adoption and use of the system.

The strength of TAM instrument lies in its parsimony; and the instrument is very easy to use with 12 straightforward questions, yet it is strongly grounded in psychological theory (Morris & Dillon, 1997). In the test items used to operationalize the constructs, only the wordings reflecting the CPOE system and the targeted professional context and population have been changed. It is an accepted practice in research studies to change the wordings such as this to sustain the original instrument validity; and many TAM studies have followed this procedure by adopting the instruments to predict technology acceptance (Davis, 1989; Lucas Jr. & Spitler, 2000; Money & Turner, 2004; Morris & Dillon, 1997; Venkatesh & Davis, 2000). All items were measured with a seven-point Likert scale with anchors "strongly agree" at one end and "strongly disagree" at the other end. Although some researchers have advocated to randomly mix the questions across different constructs with half of the items properly negated to reduce monotonous responses that could lead to potential ceiling or floor effect (Chau & Hu, 2002), Davis and Venkatesh (1996) advocated to use the test items within the constructs and without negation. They observed that mixing the questions across the constructs or with negation potentially irritates the participants. One could argue that it amounts to testing the participants' intelligence. Moreover, considering the survey fatigue due to participants' exposure to many surveys being solicited now by researchers, the present study adopted Davis and Venkatesh's original approach. All questions were worded in one way only without any negation and pooled within the constructs.

Reliability and Validity of TAM Constructs from Literature

TAM uses multiple-item scales to measure each of the above four constructs, to assure that these constructs are measured more reliably than measuring with single-item scales (Davis & Venkatesh, 1996). Davis and Venkatesh added that the Cronbach Alpha reliability of the TAM scales has generally exceeded 0.9 across various studies. Cronbach Alpha is the most commonly used reliability measure, and it is an evaluation of measurement accuracy, tracking the extent to which a respondent answers the same or similar questions the same way each time. For behavioral studies, researchers prefer Cronbach Alpha values of .60 or greater (Morris & Dillon, 1997). In addition, the scales have exhibited a high degree of convergent, discriminant, and nomological validity. Further, these strong psychometric properties, when combined with the high proportion of variations in usage, influenced by intentions to use, perceived usefulness and ease of use have led to confidence in the instrument for studying information system acceptance (Davis & Venkatesh, 1996; Morris & Dillon, 1997). Davis and Venkaetsh (1996) and Morris and Dillon (1997) added that each of these scales and the model had been extensively used in Management Information System (MIS) research.

TAM Instrument Development

In order to have to continuity of TAM research and since the present study is similar to one conducted by Davis et al. (1989), the survey design and instruments used were similar to those used by Davis et al. A one-page paper and pencil survey instrument consisting of 12 items was developed by the researcher for this study, adapting the TAM instrument developed and tested by Davis et al. (1989) and adopted by many researchers successfully in their studies (Money & Turner, 2004) (see Appendix A). The instruments used in the past research have established levels of reliability and validity, Leong and Huang (2002) used the name "MS Access" in their instruments; Amako-Gyampah and Salam (2004) adapted the instruments from past research and modified to Enterprise Resource Planning system context; and Morris and Dillon (1997) substituted their study with the name "Netscape". Similarly, in this study the questionnaire of TAM instrument was modified to CPOE context.

Technology Acceptance Model is being used to explain a specific behavior toward a specific target within a specific context (Davis et al., 1989). In the present study, TAM explains a specific behavior (usage) toward a specific target (CPOE) within a specific context (medical practice). For this study, items used in the operationalization of the four constructs (perceived usefulness, perceived ease of use, behavioral intention to use, and system usage) were adopted from previous research. The adopted items were well validated and wording changes were made to suit the instrument for this study.

The four-item scales of perceived usefulness and perceived ease of use were adapted from Venkatesh and Davis (2000), and modified to CPOE context. For the perceived usefulness construct, the words *the system* were replaced with the word *CPOE* in each of the four items. The context of *Job* in questions 1, 3, and 4 was replaced with the word *practice.* The second question talked about *productivity*, and hence that part of the item was presented as it was presented in Venkatesh and Davis' questionnaire. For the perceived ease of use construct, the words *the system* were replaced with the word *CPOE* in each of the four items.

For the behavioral intention to use construct, the two items were adapted from Morris and Dillon (1997), and modified to CPOE context. For this study, the questions "I intend to use Netscape during the remainder of the semester" was changed to "I intend to use CPOE in my practice," and "I intend to use Netscape frequently this semester" was changed to "I intend to use CPOE frequently in my practice." Morris and Dillon administered their TAM instrument to students at the start of the semester in a major Midwestern American university, to find the acceptance of Netscape. Changes were made from the words *this semester* to *my practice*.

For the usage construct, the two items were adapted primarily from Davis, Bagozzi, and Warshaw's (1992) and Lucas Jr. and Spitler's (2000) studies. However, Davis et al. did not provide the Cronbach's Alpha, the reliability value, for the usage construct. Lucas Jr. and Spitler's (2000), who have adapted Davis' TAM instrument have provided the Cronbach's Alpha values for the USAGE construct, and that was given in the Table 1. In both questions, the word *workstation* was changed to *CPOE*. The first item, "At the present time, I consider myself to be an extremely frequent user of the workstation" was changed to "At the present time, I consider myself to be a very frequent user of CPOE." The second item, "I currently use the workstation continuously throughout the day" was changed to "I currently use CPOE continuously throughout my practice."

Pilot Test

In order to ensure content validity, the researcher worked closely with two professors of health informatics program at the University of Minnesota in designing the instrument. These experts reviewed the questions for proper wording, clarity of instructions, whether the items represent the content and measure the intended variable; and they checked if the format and instrument are appropriate for the sample. A professor emeritus of medical informatics and computer science at the University of California, Davis, also provided valuable feedback of the contents of the instrument. In addition, a consultant cardiologist from Madras, India, who visited the researcher at

Minnesota also reviewed the instrument and provided valuable feedbacks. Seeking feedback from a physician of a developing country such as India was considered useful with regard to potential future research activities of extending the applicability of this model to physicians in India. This particular physician has also completed a visiting fellowship at the Mayo Clinic in Rochester, Minnesota. Valuable feedback about the instrument has also been provided by the chair of the dissertation committee. In addition, the dissertation committee members asked the researcher to identify the words that were changed from the adapted TAM instruments to suit this sample, and a revised proposal was submitted with these amendments. Finally, one of the primary TAM researchers, Michael Morris reviewed the instrument for applicability to this sample of physicians. The pilot study was limited to the above minor adjustment measures, which is consistent with the practices adopted by the TAM researchers. These pilot test procedures replicate those of Venkatesh and Davis (2000) who, for their 2000 TAM study, conducted a pretest with five business professionals and made minor changes to the instrument. Leong and Huang (2002) employed a similar pilot test with students for their TAM study. The variables' summary, definition, operationalization, and their associated reliabilities in Cronbach Alpha values are furnished in Table 1.

Table 1

Variable Summary.[3]

Variable	Definition	Operationalization	Reported Reliability
Perceived Usefulness (PU)	The degree to which a user believes that using the system will enhance performance	Perceived Usefulness Four-Item Scale (Venkatesh & Davis, 2000)	Cronbach alpha ranged from .87 to .98 across studies and time periods
Perceived Ease of Use (PEOU)	The degree to which a user believes that using the system will be free from effort	Perceived Ease of Use Four-Item Scale (Venkatesh & Davis, 2000)	Cronbach alpha ranged from .86 to .98 across studies and time periods
Behavioral Intentions to Use (BI)	The strength on one's intentions to use the technology in the future	Behavioral Intentions Two-Item Scale (Morris & Dillon, 1997)	Cronbach alpha of .91
Usage	Self-reported assessment of user behavior	Usage two-item scale (From Davis, Bagozzi, & Warshaw, 1992; adapted by Lucas & Spitler, 2000)	Cronbach alpha of .73

[3]From Davis, Bagozzi, & Warshaw, 1992; Morris & Dillon, 1997; Lucas & Spitler, 2000; Venkatesh & Davis, 2000; Summarizes TAM variables definition, operationalization, scales used; and their associated reliabilities.

Research Hypotheses

Based on the revised TAM (Figure 2, Chapter 1) and its description, the following research hypotheses were tested:

H1: Perceived *ease of use of CPOE* will have a significant positive influence on perceived *usefulness of CPOE.*

H2: Perceived *ease of use of CPOE* will have a significant positive influence on *behavioral intention to use CPOE.*

H3: Perceived *usefulness of CPOE* will have a significant positive influence on *behavioral intention to use CPOE.*

H4: *Behavioral intention to use CPOE* will have a significant positive influence on *CPOE usage.*

H5: *Perceived usefulness* and *ease of use of CPOE* will have a significant combined positive influence on *behavioral intentions to use CPOE.*

H6: *Perceived usefulness* and *ease of use of CPOE* will have a significant combined positive influence on *CPOE usage.*

Data Collection

A completed application was submitted to Institutional Review Board (IRB) of the University of Minnesota and the Human Subjects Review Board of Bowling Green State University. After approval from both review boards, the surveys were mailed to the 100 physicians practicing at the Buffalo hospital. Every physician from the mailing list provided by the Allina management received a one-page survey (Appendix A), a one-page cover letter (Appendix B), a letter from the researcher to fellow physicians with a token gift (Appendix C), an endorsement and support letter from Allina providing access to this research (Appendix D), and a self-addressed stamped envelope to return the completed survey. A token gift of two dollars was included in the mailing packet to all recipients' of the survey, for the recipients' anticipated help with the survey, irrespective of whether they returned the completed survey. In addition, all recipients of the survey were assured that they would receive an executive summary of the study as soon as the study is completed. The above items were included in a University of Minnesota envelope with a confidential sticker pasted on each envelope so that physicians themselves would receive and open the survey rather than the secretaries or other intermediary staff. This confidential sticker would have further helped them to distinguish it from other mail.

A confidentiality statement by the researcher was included in the letter of introduction to assure the respondents that confidentiality of the data would be ensured fully by limiting the access of the data to the researcher, members of the dissertation committee, and those individuals or departments involved in the analysis of the data. The letter of introduction appears in Appendix B. In addition, the information will be reported or published only in aggregate form.

Additionally, participants were requested not to write their names on the return envelope in order to eliminate the possibility of linking information back to the respondent. The survey instrument was designed to collect anonymous data. The survey instrument did not contain any identifying marks, and quotes were not solicited from the participants. They needed to only circle the responses. No demographic information was requested in this survey, as the main purpose of the study was to examine physician acceptance of CPOE system in an organization. Moreover, requesting demographic information from the subjects was considered unnecessary, as that information would not have been used in any manner in this study. This procedure is also consistent with past TAM studies (Amoako-Gyampah & Salam, 2004; Brown et al., 2002; Chau & Hu, 2002; Davis, 1989; Davis, 1993; Davis et al., 1989; Lucas Jr. & Spitler, 2000; Money & Turner, 2004; Szajna, 1996; Venkatesh & Davis, 2000). In addition, asking the subjects to provide demographic information may be a deterrent for some of them to return the surveys because employed physicians could fear that the management would tag their responses. Conducting the survey with total anonymity and confidentiality as proposed in this study could lead to more honest responses from participants, as they know it is impossible for the researcher or anyone to link the response to the respondent.

The surveys were mailed during the third week of March, 2006. The physicians were requested to complete and return the survey within 10 days. After 10 days, a personalized reminder was sent to all participants requesting them to respond, if they have not done so earlier. A special note was mentioned to those who returned the surveys to excuse this inconvenience and ignore the reminder. This method was followed because there was no way to identify the respondents from those who have not yet responded. In addition, the participants of the survey were also reminded about the importance of the survey with a request to spend a maximum of 10 minutes of their valuable time to encourage them to complete and return the survey. A similar second reminder was also sent after a week. Following the above said measures were considered good for the study to facilitate a high response rate of surveys, taking into account the small population and the need to get a bigger sample of the population for analysis.

Data Analysis

Primary Analytical Technique

Consistent with principal research studies, this study used multiple regression as the primary analytical technique for testing the hypotheses (Davis, 1993; Davis et al., 1989; Davis & Venkatesh, 1996; Morris & Dillon, 1997; Venkatesh & Davis, 2000). The above cited research studies have avoided the use of Structural Equation Modeling for hypothesis testing because the two-item scales in a measurement model could introduce problems of under-identification, resulting in instability of parameter estimates (Venkatesh & Davis, 2000). In addition, considering the small size of the accessible population of 100 physicians, the statistical analyses will be limited only to regression and correlation techniques.

Specifically, hierarchical multiple regression technique will be used to assess the model and the influence of each construct in determining the CPOE usage by physicians. Hierarchical regression analysis permits the researcher to control other variables in the model when examining the specific contribution of each variable in the model (Morris & Dillon, 1997). Further, the researcher, not a computer, determines the order of entry of the variables in this technique. Morris and Dillon added that the hierarchical multiple regression technique is also used to define the order of entry of variables when the study is based on a theory; and a preferred technique in studying models such as TAM that may involve a series of intermediate variables, which are dependent variables with respect to some other independent variables, but are themselves independent variables with respect to the ultimate dependent variable namely CPOE usage.

Finally, the effects analysis will be carried out with their relative standardized regression coefficient (β) scores or weights, as carried out in Davis' 1993 study (Davis, 1993). The strength of the individual paths will be analyzed with the respective β weights. The total causal effects of one construct on another will be assessed by summing up direct and indirect effects through the mediating constructs.

Scale Assessment

It is necessary to establish that the scales used in this study are both construct-valid and reliable (Morris & Dillon, 1997). In order to assess the construct validity for each of the scales used in this research, a principal component analysis was carried out. Similarly, reliability or internal consistency of the scales used in this research was assessed by computing Cronbach alpha coefficients (Leong & Hunag, 2002). These analyses are presented in Chapter 4. The hypotheses, the data source, and the statistical analytical technique used in this study are furnished in Table 2.

Table 2

Methodology Summary

Hypotheses	Data Source	Data Analysis
H1: Perceived *ease of use of CPOE* will have a significant positive influence on perceived *usefulness of CPOE.*	Physician adoption Survey	Simple regression
H2 Perceived *ease of use of CPOE* will have a significant positive influence on *behavioral intentions to use CPOE.*	Physician adoption Survey	Multiple regression
H3: Perceived *usefulness of CPOE* will have a significant positive influence on *behavioral intentions to use CPOE.*	Physician adoption Survey	Multiple regression
H4: *Behavioral intentions to use CPOE* will have a significant positive influence on *CPOE usage.*	Physician adoption Survey	Simple regression
H5: *Perceived usefulness and ease of use of CPOE* will have a significant combined positive influence on *behavioral intentions to use CPOE.*	Physician adoption Survey	Multiple regression
H6: *Perceived usefulness and ease of use of CPOE* will have a significant combined positive influence on *CPOE usage.*	Physician adoption Survey	Multiple regression

CHAPTER IV. RESULTS

This chapter describes the various analytical procedures applied to evaluate the data and presents the results from those procedures. First, this chapter addresses the survey responses, and how the non-response bias issue was addressed. The second section deals with data analysis and descriptive statistics. The third section describes the scale assessments that include factor analysis and reliability analysis for all the scales used in this survey. Fourth, the statistical techniques, specifically the hierarchical multiple regressions, used in the hypotheses testing and the results are furnished. Finally, the various paths were presented with their relative standardized regression coefficients (β), and the significant paths were mapped to carry out the *effects analysis,* thus helping to estimate the total causal effects of each independent variable on the dependent variable *CPOE usage,* the surrogate for CPOE adoption.

The following notations or abbreviations are used in text, tables, and in the regression equations in this chapter:

PU = Perceived Usefulness of CPOE

PEOU = Perceived Ease of Use of CPOE

BI = Behavioral Intention to use CPOE

USAGE = CPOE Usage

Sample, Respondents, and Analysis of Non-response Issues

All 100 physicians from the mailing list provided by the Allina management were mailed the one-page survey and asked to participate in this study. Three surveys were not deliverable, and one survey was mailed back to the researcher with a note that the particular physician had retired from service. From this sample, 61 surveys were returned. Of this, two were returned blank with a note indicating that they were not users of CPOE. These two were not considered as survey responses, and their intent to inform the researcher that they were not users of CPOE, probably, was also to return the prepaid two dollars that had been enclosed as a token gift. Returning two dollars to the researcher for not helping with the survey could have been the motive for them to return the blank survey. Therefore, only 59 surveys were considered as true responses to the mailed-in-surveys. Of this, six responses were not usable resulting in 53 usable surveys. The six responses were not usable due to respondents not answering all twelve questions, responding with more than one response to a question, or striking out questions in the survey.

What is considered a reasonable response rate for physicians is subject to debate, considering physicians' work load, high stress, and demands on their time requiring detailed attention to patients. The satisfaction survey of the physician order entry system conducted at the Brigham and Women's hospital in Boston, recorded a 56% response rate for physicians (Lee et al., 1996). Murff and Kannry (2001) studied the physician satisfaction of physician order entry systems used at the Mount Sinai hospital and the Bronx Veterans Affairs hospital in New York, and recorded a survey response rate of 63% and 64%, respectively, for physicians. In the present study, 59 responses for the eligible sample of 94 physicians (100 minus three undeliverable surveys, two non-users of CPOE, and one retired physician) have a response rate of 62.7%. However, the effective responses were 53, or 53% effective response rate for the 100 mailed questionnaires, and this can be considered as a reasonable response rate for physicians.

The six unusable surveys were screened to determine whether there was any pattern for missing values. The only pattern that emerged was that four of these respondents did not respond properly with respect to the behavioral intention to use construct. Two of them left a question unanswered; one of them left both questions unanswered; and the other struck out both questions. The reason for this anomaly is unknown; however, leaving a question unanswered may also be due to using several indicator variables, which sound similar in meaning, for each construct. In anticipation of this behavior of leaving out a question unanswered in the survey, a note was specially mentioned in one of the cover letters (two cover letter were sent initially; one in BGSU letterhead, and another in the University of Minnesota letterhead) to answer all twelve questions in order for the survey to be counted as a valid one for this study.

The Statistical Package for the Social Sciences (SPSS) computer program was used for the statistical analysis. Missing values in the survey questionnaire is one of the problems faced in research (George & Mallery, 2000). George and Mallery noted there are several ways to address this problem such as substituting a mean for the missing values or using a list-wise option in SPSS, or deleting the cases totally. List-wise option was not a preferred option in this study, since each hypothesis is tested with a separate regression model (i.e., the dependent and independent variable(s) selection was based on a theory) and the number of cases analyzed with each regression model would differ. The researcher wanted to avoid this scenario. The required minimum ratio of valid cases to independent variables is 5:1 (Schwab, 2000). For all variables used in this study, an index, or average score for each construct was created. Therefore, 15 valid cases were considered the required minimum for the three independent variables (average score of each construct) used in this study. Since the number of cases meets the minimum requirement for multiple regressions, the researcher took the stand, in order to preserve the purity of research, to delete all the six cases that even had one missing value in consistent with past TAM studies (Lucas Jr. & Spitler, 2000; Money & Turner, 2004). This resulted in 53 usable responses.

The effective response rate was reasonable but not very high, and therefore, the important issue of non-response bias should be addressed since non-response is a potential source of bias in studies using surveys (Hu et al., 1999). Physicians are considered a more homogeneous group with regard to knowledge, training, and attitudes than the general population, and it is believed that responding and nonresponding physicians have similar characteristics (Kellerman & Herold, 2001). Moreover, with regard to this study, the whole population is from a single organization, and was given similar training in CPOE; and all physicians are using the same CPOE system. Although one could expect that this population is homogeneous, in order to be sure that non-respondents did not differ from respondents, there is an alternative method to address this non-response issue by comparing the early and late respondents (Lahaut et al., 2003). Lahaut et al. added that the basic premise with this approach is that every subject in the study population takes a stand with respect to responding to the survey on a response continuum from “will never respond” to “will always respond,” on either ends of the spectrum. Lahaut et al. noted that late respondents are used as a proxy for non-respondents since late respondents would not have responded had the data collection stopped earlier without reminders, and those late respondents needed more reminders to respond. Although this is an assumption, this approach is widely employed to test non-response bias in survey studies, and it is known as the continuum of resistance model (Lahaut et al., 2003).

Early respondents were those who returned the completed surveys within the 10-day period and before the reminders were sent. Late respondents were those who returned the completed surveys after the two reminders. Although two reminders were sent, those who responded after the first reminder as well as after the second reminder were all classified as late respondents. There were 33 early respondents and 20 late respondents from the usable surveys. The independent-samples *t*-test was carried out to compare the means between early and late respondents, and to determine whether the means of these two samples did not differ significantly. The basic premise in carrying out this test is to suggest that the threat of non-response bias is not a serious one if there were no significant difference between the early and late respondents.

Table 3, the independent-samples *t*-test, presents the analysis of non-response bias showing the means and standard deviations of the four constructs PEOU, PU, BI, and USAGE. For the purposes of this study, PEOU, PU, BI, and USAGE are defined as follows: PEOU or perceived ease of use of CPOE was measured as the degree to which a person believed that using the CPOE system would be free from effort (Davis, 1989). PU or perceived ease of usefulness of CPOE was measured as the degree to which a person believed that using the CPOE system would improve his or her job performance (Davis, 1989). BI or behavioral intention to use CPOE was measured as the strength of a person's intentions to perform a conscious act such as deciding to accept and use the CPOE system (Ajzen & Fishbein, 1980; Chau & Hu, 2002). According to TAM, CPOE acceptance is defined as the potential user's predisposition toward personally using the CPOE system and CPOE acceptance leads to CPOE usage (Davis, 1993; Davis et al., 1989; Morris & Dillon, 1997). USAGE or CPOE Usage was measured by the self-reported estimation of usage on the job (Davis et al., 1989; Lucas Jr. & Spitler, 2000). The two groups are identified in the Table 3 as early and late respondents.

Table 3

Analysis of Non-response Biases

	Respondents	N	Mean	Std. Deviation	Std. Error Mean
PU	Early	33	-.545	1.627	.283
	Late	20	-.388	1.655	.370
PEOU	Early	33	-.765	1.537	.268
	Late	20	-.463	1.588	.355
BI	Early	33	.333	1.810	.315
	Late	20	.725	1.930	.431
USAGE	Early	33	.167	1.861	.324
	Late	20	.750	1.936	.433

Table 4 presents the *t*-statistics and the *p*-values for comparing means of two groups for each construct. The *p*-values for the *t*-tests for the two groups in PU, PEOU, BI, and USGAE are .735, .496, .460, and .281, respectively. The means of all the four constructs did not differ significantly at the $\alpha = .05$ level. Table 4 also presents the Levene's test for Equality of Variances between the groups with *F*-values and their respective significance levels of the tests. The Levene's test for Equality of Variances indicates that variances of early and late respondents did not differ significantly from each other for all the four constructs with the *p*-values of .984, .903, .701, and .597 for the constructs PU, PEOU, BI, and USAGE respectively. This test also satisfies the homogeneity of variance test, meaning that both groups' variances are equal. Based on these findings, and as late respondents are used as a proxy for non-respondents (Hu et al., 1999), one could probably assume that non-respondents would have answered the surveys similarly to late respondents and early respondents.

Table 4

Analysis of Equality of Variances and Means

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
PU	Equal variances assumed	.000	.984	-.340	51	.735	-.158	.464
PEOU	Equal variances assumed	.015	.903	-.686	51	.496	-.303	.441
BI	Equal variances assumed	.149	.701	-.745	51	.460	-.392	.526
USAGE	Equal variances assumed	.283	.597	-1.089	51	.281	-.583	.535

Data Analysis and Descriptive Statistics

Table 5 provides a brief description of the mean, standard deviation, maximum and minimum score, Skewness, and Kurtosis for each construct. The survey responses are coded with the values, as denoted in the survey instrument, of -3 to +3 with the zero being the neutral response. The means and standard deviations are in acceptable range. The means of all the four constructs are close to zero; the values of PEOU and PU are in the negative side of the zero and the values of BI and USAGE are in the positive side of the zero. The implications for these values are discussed in Chapter 5.

Table 5

Descriptive Statistics of Constructs

	N	Mean	SD	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PU	53	-.486	1.623	.685	.327	-.178	.644
PEOU	53	-.651	1.548	.357	.327	-.802	.644
BI	53	.481	1.847	-.166	.327	-.799	.644
USAGE	53	.387	1.893	-.085	.327	-1.120	.644
Valid N (listwise)	53						

The means of the individual constructs in a TAM study, such as this, have to be analyzed as a whole, rather than individually, within the context of TAM, which is based on a well-established theory. In fact, the measures of deviation from normality, Kurtosis and Skewness, of the distribution constructs' values for the four constructs are of more importance to the study, and these values should be within the acceptable range.

Measures of Deviation from Normality

Kurtosis measures whether the distribution is normal or peaked or flat, and Skewness measures the extent of deviation of distribution of values from symmetry around the mean (George & Mallery, 2000). George and Mallery added that the value of zero for Kurtosis means that the shape of the distribution is close to normal, and the value of zero for Skewness means that the distribution is evenly balanced or symmetric. For both Kurtosis and Skewness a value of $\pm$ 1.00 is considered excellent and a value of $\pm$ 2.00 is considered acceptable for psychometric purposes (George & Mallery, 2000). In this study, all values for Kurtosis and Skewness are excellent except for the USAGE variable value of -1.120 for Kurtosis, which is considered an acceptable value.

As discussed earlier, the sample population of physicians is fairly homogeneous not only by virtue of their profession, their employment, and the training received with respect to CPOE, but also due to their perceptions of the four constructs. In addition, the values of Kurtosis and Skewness of the four constructs are robust, suggesting that the shape of the distribution is close to normal, and the distribution of values are symmetrical and evenly balanced around the mean respectively. In conclusion, the data is considered good for further analysis.

Data Screening for Outliers

The data need to be screened for outliers since outliers could potentially change the results of data analysis (Schwab, 2000). Schwab defined outliers as cases that have data values that vary very much from the data values of the majority of cases in the given data set (see also Molloy & Newfields, 2005). There are mainly two reasons for outliers to occur in a data set; one is due to errors in data entry, and the other is due to including wrong data from another data set (Molloy & Newfields, 2005). Both scenarios were not possible here as there are only 53 cases and the possible values could be only between -3 and + 3, and all cases were individually checked by the researchers for any errors. However, it is not a bad idea to check for both univariate and multivariate outliers that are far distant from the rest of the data. Therefore, the data were analyzed for both univariate and multivariate outliers.

In order to check for univariate outliers, Molloy and Newfields (2005) advocated to look for the standard scores of the variables that are three standard deviations above or below the mean value of the respective variable. The Z-scores of the variables were checked and all scores of all the variables are well within in the prescribed limit. In addition, the researchers further advised to check for any unacceptable skewedness of the distribution to screen outliers. In this study, the test for skewedness is excellent for all variables with a value between $\pm$ 1.00, as shown in Table 5.

Next, the data were screened for multivariate outliers for the combination of the four variables, PEOU, PU, BI, and USAGE, by calculating the Mahalanobis distance, and the probability for the distance to identify the multivariate outliers (Schwab, 2000). Schwab noted that a value may not be a univariate outlier; however, in combination with other variables a case may turn out to be an outlier. Mahalanobis distance is considered as a type of multidimensional standard deviation (Molloy & Newfields, 2005). In order to estimate the Mahalanobis distance and the probability for the distance, a regression procedure was performed with the quantitative variables (Molloy & Newfields, 2005; Schwab, 2000; Vannatta, 1999). A new variable (mah_1) for the

Mahalanobis distances was created and tested with the chi square (X^2) criteria. The number of variables being examined is used as the degrees of freedom and so the degree of freedom in this study is 4. The critical value of X^2 at $\alpha = .001$ and $df = 4$ is 18.467, and can be found in any statistics book (Vannatta, 1999). In this study, no case had a value higher than 18.467, or any case with a value of more than .001, the probability value for the Mahalanobis distance. Studentized residuals were also requested with this regression to screen any case with a value larger than $\pm$ 3, which is a univariate outlier. Table 6, as shown below, presents the respective statistics. There are no univariate or multivariate outliers detected in this sample.

Table 6

Residuals Statistics to Detect Outliers

	Minimum	Maximum	Mean	SD	N
Stud. Residual	-1.922	1.944	-.005	1.014	53
Mahal. Distance	.344	14.218	3.925	2.756	53

Scale Assessment

Principal Component Analysis

This section discusses the methods applied to assess the scales used in this study. Principal component factor analysis with varimax rotation was used to assess the construct validity of the instrument (Davis et al., 1989; Davis & Warshaw, 1992; Leong & Hunag, 2002). Construct validity of the instrument is established when the convergent and discriminant validity of the constructs used in the instrument are found satisfactory (Chau, 1996). Based on several TAM studies, the items or indicator variables used in this study were expected to load on the respective factors or constructs. The factor loadings are the correlation coefficients between the indicator variables in the rows with the factors in the column (Garson, 1998). Factor loadings of .60 and above, according to Garson, are considered high for Likert scales. Some researchers use the .50 factor loadings as the criterion for cutoff, and any score that falls below the .50 level is to be considered for deletion.

Sampling Adequacy

University of California, Los Angeles, Academic Technology Services considers that for factor analysis sample size is very important, and a sample of 50 cases is considered very poor ("Annotated SPSS output: Factor analysis", n.d). Schwab (2000), on the other hand, opines that a minimum ratio of cases to variables should be at least 5 to 1 for principal component analysis, and the results of any such analysis performed with more than 50 cases and fewer than 100 cases should be interpreted with caution. This study has 10 indicator variables and 53 valid cases and just satisfies the minimum ratio of cases to variables. Therefore, the results of the principal component factor analysis of this study have to be interpreted with caution. However, there are other statistical measures such as anti-image correlations to test the sampling adequacy for each individual variable, and Kaiser-Meyer-Olkin measure for the set of variables

(Field, 2005; Schwab, 2000). Table 7 presents the values of anti-image correlations across the diagonal in bold face.

Table 7

Anti-image Correlation of Indicator Variables

	PU1	PU2	PU3	PU4	PEOU1	PEOU2	PEOU3	PEOU4	BI1	BI2
PU1	**.874**[a]	-.083	-.508	-.110	-.200	.264	-.388	.329	.055	-.051
PU2	-.083	**.980**[a]	-.210	-.078	.050	-.119	-.008	.005	-.008	.020
PU3	-.508	-.210	**.835**[a]	-.627	.042	-.109	.251	-.294	.213	-.220
PU4	-.110	-.078	-.627	**.885**[a]	-.035	.030	-.081	.037	-.369	.262
PEOU1	-.200	.050	.042	-.035	**.925**[a]	-.176	-.270	-.191	-.275	.255
PEOU2	.264	-.119	-.109	.030	-.176	**.860**[a]	-.548	.072	-.104	.101
PEOU3	-.388	-.008	.251	-.081	-.270	-.548	**.794**[a]	-.516	.307	-.220
PEOU4	.329	.005	-.294	.037	-.191	.072	-.516	**.887**[a]	-.106	.004
BI1	.055	-.008	.213	-.369	-.275	-.104	.307	-.106	**.715**[a]	-.911
BI2	-.051	.020	-.220	.262	.255	.101	-.220	.004	-.911	**.732**[a]

a. Measures of Sampling Adequacy(MSA)

Schwab (2000) added that the minimum value of anti-image correlation for each variable needs to be greater than .50 for pursuing with principal component analysis. That criterion is satisfied here. Similarly, the value for Kaiser-Meyer-Olkin measure for the set of variables should exceed 0.50, and it exceeds the critical value as shown in Table 8.

Table 8

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.848
Bartlett's Test of Sphericity	Approx. Chi-Square	622.236
	df	45
	Sig.	.000

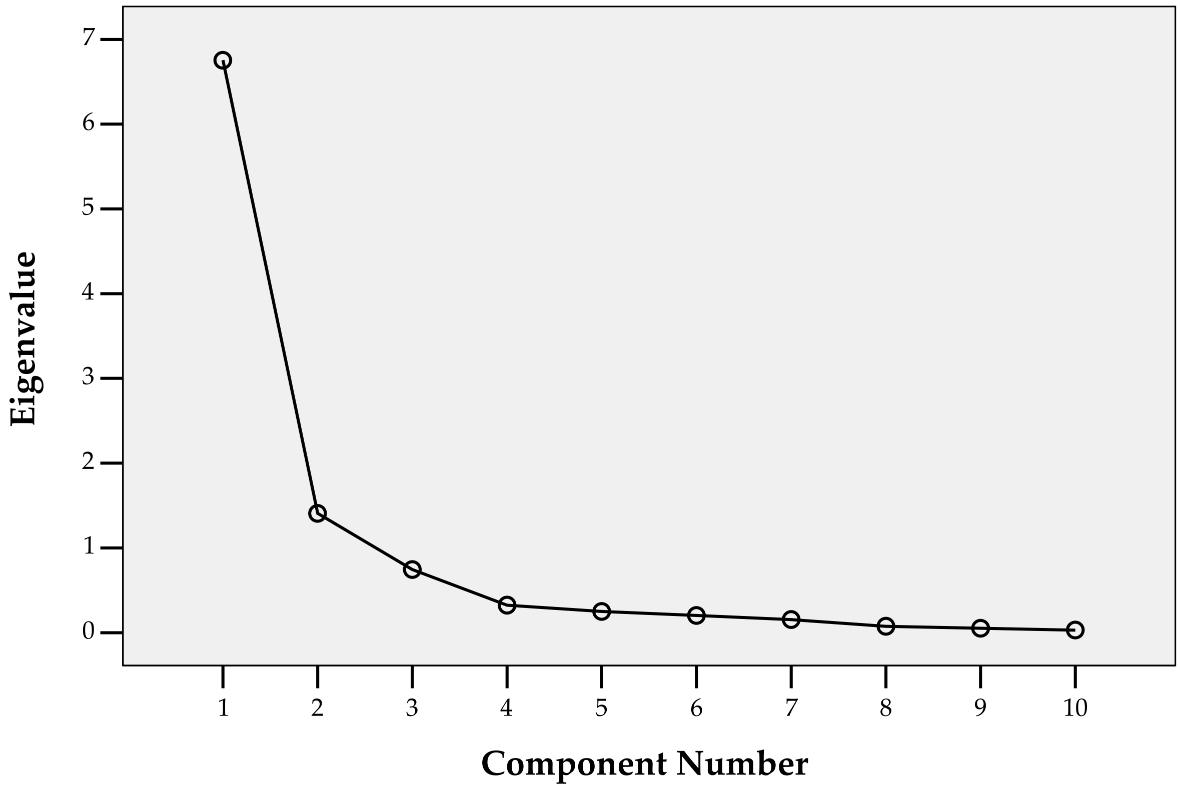
A value of .848 for the set of variables used in this study is considered good, and a value close to 1 indicates that the correlation pattern for this set of variables is good and would load with a distinct pattern of factors (Field, 2005). This measure, according to Field, varies between 0 and 1, and a value of 0 indicates that the sum of partial correlations is more than sum of correlations, and that set of variables is not a candidate for further factor analysis. This study sample satisfies both these measures adequately.

For factor analysis, there need to be relationships between the variables; however, there should not be an identity matrix, meaning the *R*-matrix of all correlation coefficients would be zero (Field, 2005). Bartlett's test has to be significant at $p < 0.05$ so as to reject the null hypothesis that the *R*-matrix is an identity matrix, and Bartlett's test is highly significant at $p < .001$, as presented in Table 8. With the assurance of both the KMO and Bartlett's tests being significant, three factors were ordered to be extracted with varimax rotation.

Factor Extraction and Rotation

There is a general disagreement between researchers as to how many factors one should extract for factor analysis (Costello & Osborne, 2005). Although most of the software packages go by the standard procedure to retain all factors with eigenvalues more than 1, Costello and Osborne argue that this is not the accurate method since some researchers prefer to use the *scree* test. The *scree* test derived its name as the plot with eigenvaules and the factors resemble the side of a mountain, and the *scree* refers to the debris lying at its base (Janda, n.d). The number of data points above the bend or the break point, not including the break point, is the number of factors to retain, and again this is an arbitrary method subject to the interpretation of the researcher (Costello & Osborne, 2005). Costello and Osborne advocate that if a researcher is able to extract fewer factors than the predicted number of factors with this *scree* method, another method is to order the number of factors extracted that is an *a priori.* The *scree* plot is presented in Figure 3.

Figure 3. Scree Plot



By looking at Figure 3, one could say that the bend is at the fourth component, and the *scree* or debris are falling after the bend, in which case the factors extracted would be three. Again, this is subject to interpretation as one could even say that the bend is actually at the third component, and the factors that could be extracted should be only two. Regardless of the view, and, consistent with an *a priori* knowledge, three factors were extracted in this study. Costello and Osborne further argue that after the rotation the one to look for is a cleanest-factor structure with all items loading above 0.30, and with no or few cross-loadings. Extracting more factors without a clean factor structure is meaningless. SPSS permits the researcher to extract factors with eigenvalues of 1 and above, or to order the number of factors to be extracted as desired by the researcher.

The researcher, based on his review of many TAM studies, has an *a priori* knowledge about how the variables are related, how they would load on each component or factor, and how many factors to be extracted for this TAM study. Therefore, the researcher ordered three factors to be extracted. Two factors were extracted with eigenvalues of 1 and above, and third factor was extracted with an eigenvalue of 0.745, as shown in Table 9. This method of extracting a factor with an eigenvalue of less than 1 is consistent with Davis, Bagozzi, and Warshaw (1992), the principal TAM researchers, who extracted four factors with three factors of eigenvalues were over 1, and the fourth factor with an eigenvalue of 0.87 in study 2.

Other than Kaiser Criterion, where dropping of components less than 1.0 eigenvalue, and the *scree* test, some researchers use the variance explained criterion in which they retain factors that account for 90%, or sometimes 80% variance, and some use Joliffe criterion by cropping all components with eigenvalues under 0.7 (Garson, 1998). In this study three factors were extracted, as shown in Table 9, and satisfy the latter two methods, as well.

Table 9

Total Variance of Components Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Comps	Total	% of Variance	Cum%	Total	% of Variance	Cum%	Total	% of Variance	Cum%
1	6.755	67.545	67.545	6.755	67.545	67.545	3.331	33.313	33.313
2	1.407	14.074	81.620	1.407	14.074	81.620	3.282	32.821	66.134
3	.745	7.452	89.072	.745	7.452	89.072	2.294	22.938	89.072
4	.325	3.250	92.322						
5	.251	2.506	94.828						
6	.204	2.036	96.864						
7	.155	1.546	98.410						
8	.076	.757	99.167						
9	.052	.519	99.686						
10	.031	.314	100.000						

Extraction Method: Principal Component Analysis.

There are three main columns in Table 9, namely (1) Initial Eigenvalues, (2) Extraction Sums of Squared loadings, and (3) Rotation Sums of Squared loadings that show eigenvalues before extraction, after extraction, and after rotation, respectively (Field, 2005). The *Initial Eigenvalues* column shows the eigenvalues of all components (10 here; one eigenvalue for each component and so a total of 10 eigenvalues), the percentage of variance, and the cumulative percentage of the variance explained. Then SPSS extracts three factors as shown in second column *Extraction Sums of Squared loadings*. The rest of the components' values not meant for extraction were discarded by SPSS in this column. The third column *Rotation Sums of Squared loadings* helps to optimize the factor structure while each factor's contribution to the total variance is equalized after rotation (Field, 2005). The three factors extracted accounts for 89% of total variance, and show the distributed variance for each factor, which is considered excellent for statistical purposes.

Communalities of Indicator Variables

Table 10 presents communalities before and after extraction. Communality is a measure of the percentage of the variance in variables that is accounted for the factor solution (Schwab, 2000). Principal component analysis assumes that the initial communalities of indicator variables are all 1 (Field, 2005). After extraction, a variable should at least account for 50% of the variance or .50 communality value in order to be retained for the final factor solution (Schwab, 2000). Communalities of the indicator variables are high suggesting that the indicator variables used in this study are appropriate and good candidates for the final factor solution.

Table 10

Communalities of Indicator Variables

	PU1	PU2	PU3	PU4	PEOU1	PEOU2	PEOU3	PEOU4	BI1	BI2
Initial	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Extraction	.904	.798	.945	.925	.826	.840	.913	.822	.970	.963

Extraction Method: Principal Component Analysis.

According to Garson (1998) a communality value is considered good and meaningful only when the factor on which the variable loads is interpretable.

Factor Loadings of Indicator Variables on Components

Table 11 presents the rotated components matrix, and the indicator variables' respective factor loadings. The indicator variables are shown as rows and the components or factors are shown as columns. The respective factor loadings are shown in bold face.

Table 11

Rotated Component Matrix with Indicator Variables' Factor Loadings

	Components		
	1	2	3
PU1	**.829**	.382	.266
PU2	**.815**	.306	.199
PU3	**.830**	.348	.369
PU4	**.793**	.354	.414
PEOU1	.422	**.772**	.228
PEOU2	.182	**.895**	.075
PEOU3	.372	**.875**	.095
PEOU4	.362	**.762**	.333
BI1	.303	.171	**.922**
BI2	.298	.157	**.922**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 5 iterations

The square of the factor loadings value of 0.707 provide the variance accounted by the respective indicator variable, which is 50%. The factors have significant factor loadings of above 0.707, and load on the respective factors or components, and this pattern is consistent with many TAM studies (Davis et al., 1989, 1992; Leong & Hunag, 2002; Morris & Dillon, 1997; Venkatesh & Davis, 2000). Although the cutoff point for factor loadings is 0.50, there are two factor loadings above 0.40 that need to be addressed. PU4 has a cross-factor loading of .414 on the third component, and PEOU1 has a cross-factor loading of .422 on the first component. This phenomenon of cross-loadings on other constructs is fairly common in TAM studies, as researchers Gefen, Struab, and Boudreau (2000) noted that a "downstream effect like the attitude toward use, intention to use, or use may actually cross-load on PU or PEOU since these are casually (sic) related." (Association for Information Systems, n.d). The convergent and discriminant validity of the instruments are well established as the items intended to measure the same construct have a high factor loadings of 0.70 and above on a single component than on other components (Hu et al., 1999). In addition to an item loading on a single component of 0.70 and above, there are no cross loadings of 0.50 and above on other components. The factor loadings are in acceptable range, considering the size of the sample, although some TAM studies have recorded much higher factor loadings (Venkatesh & Davis, 2000).

Reliability Analysis and Correlations of Constructs

The reliability analysis or internal consistency analysis of the items used in this study was assessed with Cronbach's Alphas, as shown in Table 12, and they exhibit excellent psychometric properties being close to 1 (Chau, 1996; Davis et al., 1992; Leong & Hunag, 2002; Morris & Dillon, 1997).

Table 12

Reliability Analysis of Constructs

Constructs	Indicator Variables (Items)	Cronbach's Alphas
Perceived Usefulness (PU)	4	.957
Perceived Ease of Use (PEOU)	4	.931
Behavioral Intentions (BI)	2	.970
System Usage (USAGE)	2	.929

These analyses helped to establish the validity and reliability of the scales used in the context of physician acceptance of Computerized Physician Order Entry system by applying the Technology Acceptance Model. The correlations between constructs are significant and presented in Table 13.

Table 13

Pearson Correlations Between Constructs

	PU	PEOU	BI	USAGE
PU	1.000			
PEOU	.721	1.000		
BI	.636	.451	1.000	
USAGE	.580	.475	.780	1.000

Correlations are significant at the 0.01 level (2-tailed).
Listwise N=53

Hypotheses Testing

Based on the revised Technology Acceptance Model (TAM), as shown in Figure 2, and its description, the six research hypotheses were tested with hierarchical multiple regressions, which meant that the researcher, not the computer, determined the order of entry of the variables. The Statistical Package for the Social Sciences (SPSS) computer program was used in the regression analysis in order to test the various hypotheses. The *Enter* method was used to input the variables into the regression equation. This is a forced-entry method in which SPSS permits the researcher to enter the variables regardless of their significance levels (George & Mallery, 2000). It is important to use this technique to define the order of entry of variables when the study is based on a theory. Schwab (2000) suggests for multiple regressions, the minimum ratio of cases to independent variables is 5 to 1, and the preferred ratio is 15 to 1. Since an index or average score is used for the three constructs, the preferred ratio of 15 to 1 was also met as there are 53 valid cases in this study. In order to be consistent with the past TAM research, the analytic techniques used by Davis et al. (1989), Davis (1993), and Morris and Dillon (1997) a series of linear regression analyses were carried out to test the hypotheses and to estimate the path coefficients, identified by standardized regression weights known as Beta (β). The relative Beta (β) weights are used to estimate the direct and indirect effects of the constructs or variables as hypothesized in the study.

Research Hypotheses and Equations

Basically, the following regression models will be fit to analyze the six hypotheses:

$PU = \beta_0 + \beta_1 PEOU + \varepsilon$

$BI = \beta_0 + \beta_1 PEOU + \beta_2 PU + \varepsilon$

$USAGE = \beta_0 + \beta_1 BI + \varepsilon$

$USAGE = \beta_0 + \beta_1 PEOU + \beta_2 PU + \beta_3 BI + \varepsilon$

Based on TAM theory and consistent with several TAM studies (e.g., Davis et al. 1989; Money & Turner, 2004; Morris & Dillon, 1997), the above regression equations were developed.

For each hypothesis, three tables are provided to explain the underlying relationships between the independent variable(s) and the dependent variable: (1) Model summary, (2) ANOVA summary, and (3) the Coefficients summary.

The model summary table provides the *R*-value and the R^2-value. While the *R*-value indicates the correlation between the independent variable(s), and dependent variable, the R^2-value identifies the portion of the variance in the dependent variable accounted by the independent variable(s) (George & Mallery, 2000).

The ANOVA table provides the *F*-value and associated *p*-value (significance of F) that reflect the *overall* relationship between independent variable(s) and the dependent variable (George & Mallery, 2000).

The coefficients table provides the *t*-value and associated *p*-value (significance of t) that reflect the relationship between *individual* independent variable and the dependent variable (George & Mallery, 2000). In addition, the associated B value (absolute value) or unstandardized B coefficient helps to identify *each* independent variable's influence on the dependent variable. However, each independent variable's influence on the dependent variable cannot be compared easily because different scales and metrics could have been used in the study. George and Mallery added that in order to alleviate this problem and to allow direct comparison of relationships between variables statisticians have come out with a standardized score called Beta (β). β score or weight ranges between $\pm$ 1.0 in linear equations. It is a partial correlation between two variables after the influence of other variables has been controlled.

When a dependent variable is regressed on a *single* independent variable, the *R*-value or correlation between the dependent variable and the *single* independent variable, and the influence of the *single* independent variable, identified by the standardized regression coefficient or β value, on the dependent variable are the same. However, in order to be consistent and for clarity, all the three tables mentioned above have been presented for all hypotheses tested, even when a dependent variable was regressed on one independent variable.

Finally, the effects analysis was carried out with their relative standardized regression coefficient (β) scores or weights, as carried out in Davis' 1993 study (Davis, 1993). The strength of the individual paths was analyzed with the respective β weights. The total causal effects of one construct on another were assessed by summing up direct and indirect effects through the mediating constructs.

Each hypothesis along with the regression equation and the results are furnished below.

Hypothesis 1

H1: Perceived *ease of use of CPOE* will have a significant positive influence on perceived *usefulness of CPOE.*

$PU = \beta_0 + \beta_1 PEOU + \varepsilon,\ \beta_1 > 0$

Table 14 presents the *R*-value or correlation between the dependent variable *ease of use of CPOE* and the independent variable *usefulness of CPOE*, which is .721, and the R^2-value identifies the portion of the variance accounted by the independent variable *ease of use of CPOE* on the dependent variable *usefulness of CPOE*, which is 52%.

Table 14

Model Summary: Correlation of PEOU with PU and Variance in PU

Model	R	R Square	Std. Error of the Estimate
1	.721	.520	1.136

Table 15 shows that the *F*-statistic is statistically significant at $p<.001$, and reflects the *overall* regression relationship between the independent variable *ease of use of CPOE* and the dependent variable *usefulness of CPOE.* Note, however, in this equation we have only one independent variable.

Table 15

ANOVA: Significance of Overall Regression Relationship

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	71.236	1	71.236	55.200	.000
	Residual	65.816	51	1.291		
	Total	137.052	52			

Table 16 shows that the *t*-value of 7.430 *for ease of use of CPOE* is statistically significant at $p < .001$, and reflects that the *individual* relationship between the independent variable *ease of use of CPOE* and the dependent variable *usefulness of CPOE* is significant.

Table 16

Coefficients: Individual Influence of PEOU on PU

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.006	.170		.037	.971
	PEOU	.756	.102	.721	7.430	.000

The results show that perceived *ease of use of CPOE* has a significant positive influence on perceived *usefulness of CPOE,* as indicated by the standardized regression coefficient (β) of 0.721 and the p-value of .000, *(p<.001)* for perceived *ease of use of CPOE*. Thus, Hypothesis 1 is supported.

Hypotheses 2, 3, and 5

The TAM theory suggests that both independent variables *ease of use of CPOE* and *usefulness of CPOE* have simultaneous and direct influence on *behavioral intention to* *use CPOE to use*; and they both jointly influence *behavioral intention to use CPOE.* Therefore, both variables were entered together in the same equation and tested the hypotheses 2, 3, and 5.

H2: Perceived *ease of use of CPOE* will have a significant positive influence on *behavioral intention to use CPOE.*

$BI = \beta_0 + \beta_1 PEOU + \beta_2 PU + \varepsilon, \beta_1 > 0$

H3: Perceived *usefulness of CPOE* will have a significant positive influence on *behavioral intention to use CPOE.*

$BI = \beta_0 + \beta_1 PEOU + \beta_2 PU + \varepsilon, \beta_2 > 0$

H5: *Perceived ease of use* and *usefulness of CPOE* will have a significant combined positive influence on *behavioral intention to use CPOE.*

$BI = \beta_0 + \beta_1 PEOU + \beta_2 PU + \varepsilon, \beta_1 > 0$ and $\beta_2 > 0$

If $\beta_1 \neq 0$, then PU does not completely mediate the effect of PEOU on BI.

Table 17 presents the *R*-value or correlation between the dependent variable *behavioral intention to use CPOE* and the independent variables *ease of use of CPOE* and *usefulness of CPOE,* which is 0.637, and the R^2-value identifies the portion of the variance accounted by the both the independent variables on the dependent variable *behavioral intention to use CPOE*, which is 41%.

Table 17

Model Summary: Multiple Correlation of PEOU and PU with BI and Variance in BI

Model	R	R Square	Std. Error of the Estimate
1	.637	.405	1.453

Table 18 shows that the *F*-statistic is statistically significant at *p*<.001, and reflects the *overall* regression relationship between the independent variables *ease of use of CPOE* and *usefulness of CPOE* and the dependent variable *behavioral intention to use CPOE.*

Table 18

ANOVA: Significance of Overall Regression Relationship

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	71.918	2	35.959	17.032	.000
	Residual	105.564	50	2.111		
	Total	177.481	52			

Table 19 shows that the *t*-value of -0.103 for *ease of use of CPOE* is not statistically significant at *p*<.001, and reflects that the *individual* relationship between the independent variable *ease of use of CPOE* and the dependent variable *behavioral intention to use CPOE* is not significant. The results show that perceived *ease of use of CPOE* does not have a significant positive influence on *behavioral intention to use CPOE,* as indicated by the standardized regression coefficient (β) of -0.016 and the *p*-value of 0.919 for perceived ease of use of CPOE. Thus, Hypothesis 2 is not supported.

Table 19

Coefficients: Individual Influence of PEOU and PU on BI

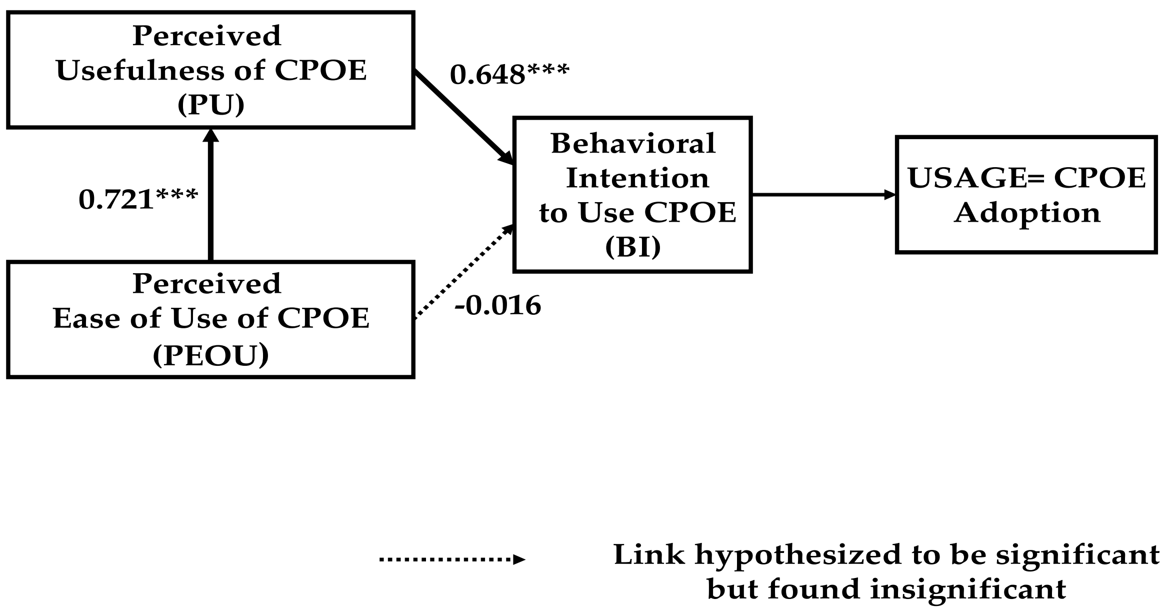
Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.827	.217		3.814	.000
	PEOU	-.019	.188	-.016	-.103	.919
	PU	.738	.179	.648	4.118	.000

However, the *t*-value of 4.118 for *usefulness of CPOE,* as shown in Table 19, is statistically significant at *p*<.001, and reflects that the *individual* relationship between the independent variable *usefulness of CPOE* and the dependent variable *behavioral intention to use CPOE* is significant. Perceived *usefulness of CPOE* has a significant positive influence on *behavioral intention to use CPOE,* as indicated by the standardized regression coefficient (β) of 0.648 and the *p*-value of .000, (p<.001) for *perceived usefulness of CPOE*. Thus, Hypothesis 3 is supported.

Analysis of Paths: PEOU→PU, PEOU→BI, and PU→BI

Although *ease of use of CPOE* has no direct causal effect on *behavioral intention to use CPOE, ease of use of CPOE* affects *behavioral intention to use CPOE* indirectly through *usefulness of CPOE*. The indirect effect of ease of use of CPOE through usefulness of CPOE on behavioral intention to use CPOE (0.721*0.648) is 0.467, as shown in Figure 4, derived by multiplying the respective standardized regression coefficient (β) score, or path weights. The indirect and causal effect of *ease of use of CPOE* **on** *behavioral* *intention to use CPOE* via *usefulness of CPOE* was calculated with their relative standardized regression coefficient (β) score or weights, for their respective paths, as carried out in Davis' 1993 study (Davis, 1993).

Figure 4. The Relative β Weights of the Paths PEOU→PU, PEOU→BI, and PU→BI



Mediating Role of Usefulness of CPOE

However, in order to confirm that *PU*, in fact, mediated the effects of *PEOU* on *BI*, and *PEOU* only had indirect effects on *BI*, it was necessary to carry out the following regressions with the results presented in Tables 20, 21, and 22. As shown in Table 20, when *BI* was regressed on *PEOU, PEOU* has a significant effect (*t*-value = 3.610, β weight = 0.451, p< .01). When *PU* was brought into the equation, *PEOU* became non-significant (*t*-value = -.103, β weight = -.016, not significant). This suggests that PU mediates the effect of *PEOU* on *BI, and PEOU* is an antecedent *to PU* (Davis et al., 1989, 1992; Ma, 2003).

Table 20

Nonsignificant Influence of PEOU on BI with PU in the Equation

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.831	.248		3.347	.002
	PEOU	.538	.149	.451	3.610	.001
2	(Constant)	.827	.217		3.814	.000
	PEOU	-.019	.188	-.016	-.103	.919
	PU	.738	.179	.648	4.118	.000

Table 21 shows that by controlling *PU* in step 1, and entering *PEOU* in the second step, the change statistics (*F* change of 0.011, R^2-value change of .000, not significant) influenced by PEOU in the regression model were not significant. The variance explained by PU in BI is 41%, and the variance explained in BI remained the same even after the addition of PEOU.

Table 21

Nonsignificant Regression Relationship of PEOU with BI Controlling for PU

				Change Statistics				
Model	R	R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.636	.405	1.439	.405	34.727	1	51	.000
2	.637	.405	1.453	.000	.011	1	50	.919

This means that *PEOU* did not account for any additional variances on *BI* over and above *PU.* In other words, *PU i*s the only variable that explains the direct influence on *BI*, and PEOU did not have any direct effect influence on BI.

Table 22 shows that controlling *PU* in step 1, and on entering *PEOU* in the second step, *PEOU* (*t*-value = -.103, β weight = -.103, not significant) did not have any significant effects on *BI* over and above *PU*. These findings further suggest that *PU* fully mediates the effects of *PEOU* on *BI.*

Table 22

Nonsignificant Influence of PEOU on BI Controlling for PU

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.833	.206		4.035	.000
	PU	.724	.123	.636	5.893	.000
2	(Constant)	.827	.217		3.814	.000
	PU	.738	.179	.648	4.118	.000
	PEOU	-.019	.188	-.016	-.103	.919

Thus, Hypothesis 5 is partially supported, as *usefulness of CPOE* has a positive direct effect on *behavioral intention to use*, but *ease of use of CPOE* only has an indirect causal effect on *behavioral intention to use* via *usefulness of CPOE*, but no combined effect.

Hypothesis 4

H4: *Behavioral intention to use CPOE* will have a significant positive influence on *CPOE usage.*

$USAGE = \beta_0 + \beta_1 BI + \varepsilon, \beta_1 > 0$

According to TAM, behavioral intention to use is a significant determinant of usage behavior (Davis, 1993; Davis et al., 1989, 1992). Since the intention-usage relationship is one of the basic TAM relationships, and to be consistent with past TAM research *CPOE usage* was regressed on *behavioral intention to use CPOE* (Davis, 1993; Davis et al., 1989, 1992).

Table 23 presents the *R*-value or correlation between the dependent variable *CPOE usage* and the independent variable *behavioral intention to use CPOE,* which is .780, and the R^2-value identifies the portion of the variance accounted by *behavioral intention to use CPOE* on *CPOE usage*, which is 61%.

Table 23

Model Summary: Correlation of BI with USAGE and Variance in USAGE

Model	R	R Square	Std. Error of the Estimate
1	.780	.609	1.195

Table 24 shows that the *F*-statistic is statistically significant at $p<.001$, and reflects the *overall* regression relationship between the independent variable *behavioral intention to use CPOE* and the dependent variable *CPOE usage.*

Table 24

ANOVA: Significance of Overall Regression Relationship

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	113.431	1	113.431	79.366	.000
	Residual	72.890	51	1.429		
	Total	186.321	52			

Table 25 shows that the *t*-value of 8.909 for *behavioral intention to use CPOE* is statistically significant at $p < .001$, and reflects that the *individual* relationship between the independent variable *behavioral intention to use CPOE* and the dependent variable *CPOE usage* is significant.

Table 25

Coefficients: Individual Influence of BI on USAGE

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.002	.170		.013	.990
	BI	.799	.090	.780	8.909	.000

The results show that *behavioral intention to use CPOE* has a significant positive influence on *CPOE usage,* as indicated by the standardized regression coefficient (β) of 0.780 and the p-value of .000, (p<.001) for *behavioral intention to use CPOE*. Thus, hypothesis 4 is supported.

Hypothesis 6

H6: *Perceived ease of use* and *usefulness of CPOE* will have a significant combined positive influence on *CPOE usage.*

$USAGE = \beta_0 + \beta_1 PEOU + \beta_2 PU + \beta_3 BI + \varepsilon$, $\beta_1 > 0$ and $\beta_2 > 0$

If $\beta_1 \neq 0$ or $\beta_2 \neq 0$, then BI does not completely mediate the effects of PEOU and PU on USAGE.

Table 26 presents the *R*-value or correlation between the dependent variable *CPOE usage* and the independent variables *ease of use of CPOE, usefulness of CPOE,* and *behavioral intention to use CPOE*, which is 0.793, and the R^2-value identifies the portion of the variance accounted by the three independent variables on the dependent variable, which is 63%.

Table 26

Model Summary: Multiple Correlation of PEOU, PU, and BI with USAGE and Varianc in USAGE

Model	R	R Square	Std. Error of the Estimate
1	.793	.629	1.188

Table 27 shows that the *F*-statistic is statistically significant at $p<.001$, and reflects the *overall* regression relationship between the independent variables *ease of use of CPOE*, *usefulness of CPOE,* and *behavioral intention to use CPOE* and the dependent variable *CPOE usage.*

Table 27

ANOVA: Significance of Overall Regression Relationship

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	117.138	3	39.046	27.655	.000
	Residual	69.182	49	1.412		
	Total	186.321	52			

Table 28 shows that the *t*-value of 6.136 for *behavioral intention to use CPOE* is statistically significant at $p<.001$, and reflects that the *individual* relationship between the independent variable *behavioral intention to use CPOE* and the dependent variable *CPOE usage* is significant. This step is essentially used to find out whether *ease of use of CPOE* and *usefulness of CPOE* have any *direct* effects on *CPOE usage* over and above *behavioral intention to use CPOE.* The *t*-value of 0.312 for *usefulness of CPOE* and the *t*-value of 1.038 for *ease of use of CPOE* are not statistically significant, suggesting that there are no direct relationships between these two independent variables and the dependent variable *CPOE usage.* Table 28 also presents the respective standardized regression coefficients or β weights of the independent variables *ease of use of CPOE, usefulness of CPOE, and behavioral intention to use CPOE* on the dependent variable *CPOE usage.*

Table 28

Coefficients: Individual Influence of PEOU, PU, and BI on USAGE

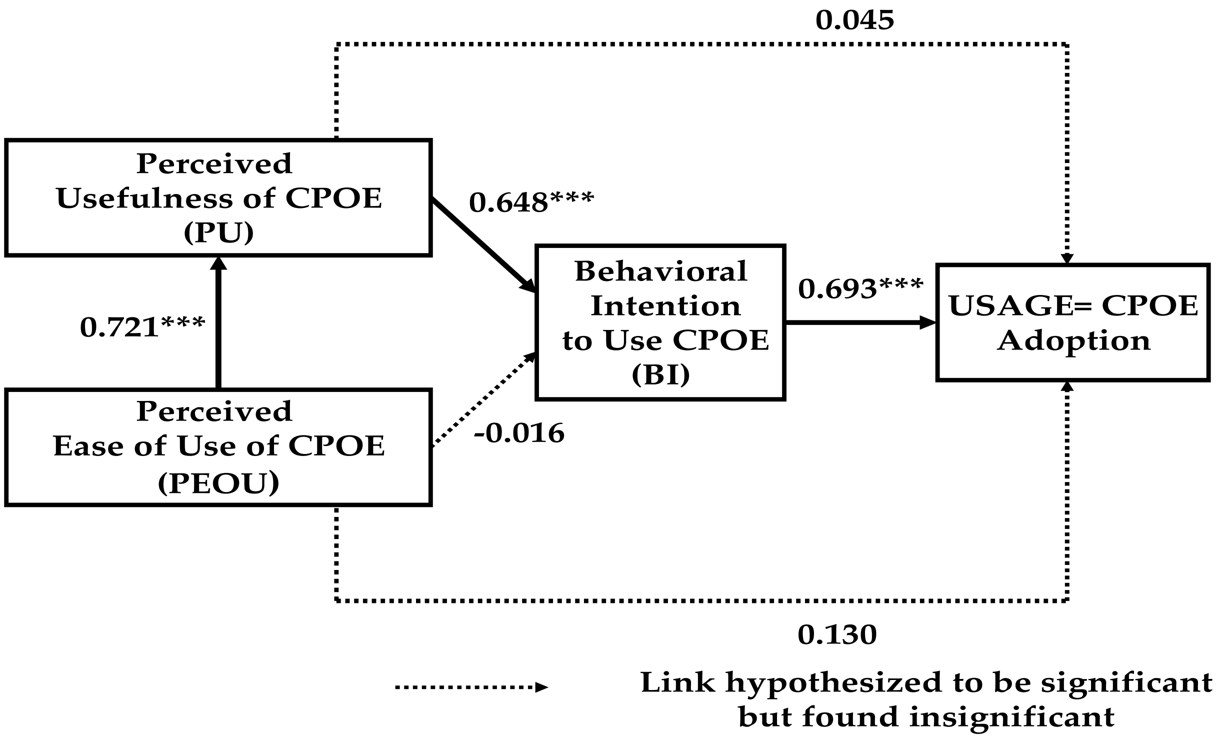
Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.175	.201		.868	.390
	PEOU	.159	.154	.130	1.038	.305
	PU	.053	.169	.045	.312	.756
	BI	.710	.116	.693	6.136	.000

The results show that *behavioral intention to use CPOE* has a significant positive influence on *CPOE usage,* as indicated by the standardized regression coefficient (β) of .693 and the *p*-value of .000, (*p*<.001) for *behavioral intention to use CPOE*. Perceived *ease of use* and *usefulness of CPOE* do not have a significant *direct* positive influence on *CPOE usage,* as indicated by the standardized regression coefficient (β) of 0.130 and the *p*-value of 0.305 for perceived *ease of use of CPOE* and standardized regression coefficient (β) of 0.045 and the *p*-value of 0.756 for perceived *usefulness of CPOE*, respectively.

Analysis of All Paths

The parameters, as shown in Figure 5, help us to calculate the relative *indirect* effects of *ease of use of CPOE* and *usefulness of CPOE* on *behavioral intention to use CPOE* and on *CPOE usage* (Davis, 1993; Garson, 1998). Michael Morris (personal communication, May 8, 2006), one of the principal TAM researchers, suggested to use the β weight of 0.693 as the best value for the effect of *behavioral intentions to use CPOE* on *CPOE usage* derived when *CPOE usage* was regressed on all three independent variables *ease of use of CPOE, usefulness of CPOE,* and *behavioral intention to use CPOE*.

Figure 5. The Relative β Weights of the Paths PEOU→PU, EOU→BI, PU→BI, PEOU→USAGE, PU→USAGE, and BI→USAGE



Morris suggested using this value, instead of β weight of 0.780 obtained (Hypothesis 4) when *CPOE usage* was regressed *only* on *behavioral intention to use*, as the *ease of use of CPOE* and *usefulness of CPOE* variables together with *behavioral intention to use* in the regression equation are necessary to control for any potential shared variance between the constructs. Similarly, the β weight of 0.648 was used for the effect of *usefulness of CPOE* on *behavioral intention to use CPOE* with *ease of use of CPOE* in the regression equation. Fred Davis (personal communication, April 28, 2006), the researcher who developed TAM model, suggested to calculate the path weights along similar lines, and the since the direct path of *ease of use of CPOE* to *behavioral intention to use CPOE* is not statistically significant that path and its value should not be used to calculate the indirect effect of *ease of use of CPOE* on *CPOE usage.*

There is no direct effect of *ease of use of CPOE* on *behavioral intention to use CPOE* or on *CPOE usage*. The indirect effect of *ease of use of CPOE* through *usefulness of CPOE* on *behavioral intention to use CPOE* (0.721*0.648) is 0.467. The indirect effect of *ease of use of CPOE* on *CPOE usage* through *usefulness of CPOE* and *behavioral intention to use CPOE* (0.721*0.648*0.693) is 0.328.

The direct effect of *usefulness of CPOE* on *behavioral intention to use CPOE* is 0.648. The indirect effect of *usefulness of CPOE* on *CPOE usage* through *behavioral intention to use CPOE* (0.648*0.693) is 0.449. Thus, hypothesis 6 is partially supported considering the *indirect* causal effects of *ease of use of CPOE* and *usefulness of CPOE* on *CPOE usage,* and no *direct* effects of *ease of use of CPOE* and *usefulness of CPOE* on *CPOE usage* over and above *behavioral intention to use CPOE.*

Mediating Role of Behavioral Intention to Use CPOE

Consistent with past TAM studies, the following hierarchical regressions were carried out, as shown in Tables 29, 30, and 31, to confirm that the *behavioral intention to use CPOE* fully mediated the effects of *usefulness of CPOE* on *CPOE usage,* and the indirect effects of *ease of use of CPOE* through *usefulness of CPOE* on CPOE usage.

As shown in Table 29, when *CPOE usage* was regressed on *ease of use of CPOE* and *usefulness of CPOE, usefulness of CPOE* has a significant effect (*t*-value = 2.989, β weight = 0.494, $p < .01$), but ease of use of CPOE does not (*t*-value = 0.721, β weight = .119, not significant). When *behavioral intention to use CPOE* was brought into the equation, *usefulness of CPOE* became non-significant (*t*-value = .312, β weight = .045, not significant). This suggests that *behavioral intention to use CPOE* mediates the effect of *usefulness of CPOE* on *CPOE USAGE.*

Table 29

Nonsignificant Influence of PU on USAGE with BI in the Equation

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.762	.233		3.263	.002
	PEOU	.146	.202	.119	.721	.475
	PU	.576	.193	.494	2.989	.004
2	(Constant)	.175	.201		.868	.390
	PEOU	.159	.154	.130	1.038	.305
	PU	.053	.169	.045	.312	.756
	BI	.710	.116	.693	6.136	.000

Table 30 shows that controlling *behavioral intention to use CPOE* in step 1, and on entering *ease of use of CPOE* and *usefulness of CPOE* in the second step, the change statistics (*F* change of 1.313, R^2-value change of .020, not significant) suggest that the relationship after the addition of these two variables is not significant with the dependent variable *CPOE usage*. This means that *ease of use of CPOE* and *usefulness of*

CPOE do not account for any additional variance in *CPOE usage* over and above *behavioral intention to use CPOE.*

Table 30

Nonsignificant Regression Relationship of PEOU and PU with USAGE Controlling for BI

				Change Statistics				
Model	R	R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.780	.609	1.195	.609	79.366	1	51	.000
2	.793	.629	1.188	.020	1.313	2	49	.278

Table 31 shows that controlling *behavioral intention to use CPOE* in step 1, and on entering *ease of use of CPOE* and *usefulness of CPOE* in the second step, both *ease of use of CPOE* (*t*-value = 1.038, β weight = .130, not significant) and *usefulness of CPOE* (*t*-value = .312, β weight = .045, not significant) do not have any significant effects on *CPOE usage* over and above *behavioral intention to use CPOE*.

Table 31

Nonsignificant Individual Influence of PEOU and PU on USAGE Controlling for BI

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.002	.170		.013	.990
	BI	.799	.090	.780	8.909	.000
2	(Constant)	.175	.201		.868	.390
	BI	.710	.116	.693	6.136	.000
	PEOU	.159	.154	.130	1.038	.305
	PU	.053	.169	.045	.312	.756

These findings suggest that *behavioral intention to use CPOE* fully mediates the effects of *usefulness of CPOE,* and the effects of *ease of use of CPOE* through *usefulness of CPOE* on *CPOE usage.* Of the six hypotheses tested, hypotheses 1, 3, and 4 were strongly supported. Hypotheses 5 and 6 were partially supported as explained earlier. Hypothesis 2 was not supported. The Figures 4 and 5 helped to explain the total causal effects of *usefulness of CPOE* and *ease of use of CPOE*, the two central construct of TAM, on *behavioral intention to use CPOE* and *CPOE USAGE, the surrogate for CPOE* adoption.

CHAPTER V. DISCUSSION AND CONCLUSION

Introduction

As discussed earlier, this study attempted to explain a specific behavior, usage of Computerized Physician Order Entry (CPOE), toward a specific target (CPOE) and within a specific population and context (physicians of an organization). Three major objectives have been achieved with this CPOE adoption study. First, the study attempted to further validate the Technology Acceptance Model (TAM) within an organizational context by studying the physician usage behavior of CPOE. TAM is one of the important and major contemporary models applied to study technology acceptance of users (Legris et al., 2003; Morris & Dillon, 1997; Venkatesh & Davis, 2000); however, TAM studies conducted in organizations are not often compared to the studies, like the present one, conducted in academic settings. Therefore conducting one such study in an organization among physicians assumes more importance.

Second, implementation of CPOE is considered a major organizational activity by the chief information officers in two major leadership surveys (Kini & Savage, 2004). Overcoming barriers to implementing and adopting CPOE by physicians is critical (Poon et al., 2004). Understanding user acceptance of CPOE by applying TAM could shed some light into breaking the barriers to successful implementation and adoption. It is important to note, in light of the present research, Davis' (1989) observation that big organizations such as IBM, Xerox, and Digital Equipment Corporation used subjective and non-validated measures to study the user acceptance of new systems, and important business decisions were made with misinformation about system's acceptability to users. The present study provides practitioners with a valid instrument to study the acceptance of CPOE system and/or adoption of the CPOE system. The by-product of this research, a validated survey instrument to study physician acceptance and adoption of CPOE, could also provide a platform to study the influence of other external factors (variables) added to this model and study the impact of those factors on the physician acceptance and/or adoption of CPOE within in an organization.

Third, combining three major areas of interests in this study -- validating TAM to a new population of physicians, electing to study the adoption of CPOE, and studying the adoption of a technology within an organization context -- would contribute richly to research literature in these three domains. This chapter discusses the analyses of the six hypotheses tested, the results interpreted, and how this data set fits the revised Technology Acceptance Model. The final section will conclude with the implications for present and future research, and how they are useful to the theory and practice.

Discussion

With respect to this research, specifically, two major questions were addressed:

1. What are the constructs or variables that influence the physicians' use of the Computerized Physician Order Entry system (CPOE)?

2. What are the relationships among the constructs or variables that influence physicians' use of CPOE?

In order to address these questions six TAM-derived hypotheses were developed and tested. The results of the six hypotheses were presented in Chapter 4, and the analysis and discussion of the six hypotheses will be discussed in this section.

Of the six hypotheses adapted to CPOE context in this study, the first five have been used routinely with TAM studies (Money & Turner, 2004; Morris & Dillon, 1997). The sixth hypothesis, "*Perceived ease of use* and *usefulness of CPOE* will have a significant combined positive influence on *CPOE usage,"* was developed and tested for the present study because of mixed research findings in earlier studies.

Hypothesis 1

Hypothesis 1 was well supported, as perceived *ease of use of CPOE* (PEOU) had a significant positive influence on perceived *usefulness of CPOE* (PU). The results of this hypothesis were presented in Tables, 14, 15, and 16. The overall regression relationship between *PEOU* and *PU* was statistically significant at $p < .001$, and the *R*-value or correlation between these two variables was .721. In this study, the correlation of .721 between *PEOU* and *PU* was considered strong (Schwab, 2000). The amount of variance (R^2) in *PU* explained by its relationship with *PEOU* was 52%. The standardized regression coefficient or the β value of .721 ($p<.001$) indicates that there is direct significant positive effect of *PEOU* on *PU.* The results are consistent with past TAM studies. Davis (1993) noted direct significant positive effect of *PEOU* on *PU* with a β value of .630. Davis et al. (1989) hypothesized that PEOU is one of the antecedents to PU in addition to the effects of external variables. Several TAM studies confirmed this hypothesis and found PEOU as antecedent to PU (Davis, 1989; Davis, 1993; Davis et al., 1989; Ma, 2003; Morris & Dillon, 1997; Szajna, 1996). Similarly, in this study, the *ease of use of CPOE* is antecedent to *usefulness of CPOE*, which will be discussed with the analysis of the hypothesis 5.

Hypotheses 2, 3, and 5

Hypothesis 2 stated that perceived *ease of use of CPOE* would have a significant positive influence on *behavioral intention to use CPOE.* The results suggest that there is no direct effect of *PEOU* on *behavioral intention to use CPOE* (*BI*). Both *PEOU* and *PU* were entered together in the regression model, based on TAM theory, as independent variables with *BI* as the dependent variable. Having the effect of *PU* on *BI* controlled, the direct effect *PEOU* on *BI* is less than or equal to zero with a β value of -.016, not statistically significant. The results of the hypothesis 2 were presented in Tables 17, 18, and 19. Hypothesis 2 was not supported.

However, the total variance explained in *BI* by this regression model with both *PEOU* and *PU* together is 41%. Although the variance explained in *BI* is consistent with past TAM studies (Venkatesh & Davis, 2000), the total variance in *BI* is accounted *only* by *PU* with *PEOU* contributing nothing to the variance (see Table 21). The variance accounted by *PEOU* in *BI* is zero as shown by the insignificant regression relationship of *PEOU* with *BI* when the effect of *PU* was controlled. Further, the results presented in Tables 20, 21, and 22 show that the effect of *PEOU* on *BI* is only *indirect* and all of its effects were mediated by *PU* on *BI.* Similarly, Szajna (1996) in a post-implementation study found the path *PEOU* to *PU* significant, and the effect of *PEOU* on *BI* was primarily through *PU*. It is not uncommon in TAM studies to find that *ease of use* has no direct effects on either *behavioral intention to use or system usage* in the post-implementation period studied of longer durations (Szajna, 1996). After a period of actually using the information system, especially during the post-implementation period, according to Szajna, the perceived ease of use has only *indirect* effects on *behavioral intention to use* through *usefulness,* and ultimately on *system usage.* Szajna has modeled and conducted a TAM study without positing the direct effect of *ease of use* on *behavioral intention to use* (Szajna, 1996).

Davis et al. (1989) and Venkatesh and Davis (2000) noted the effect of *PEOU* on *BI* and ultimately on *USAGE* was primarily through *PU* as the effect of *PEOU* decreased with experienced users, and *PEOU* had mostly indirect effects on *BI* and *USAGE* in experienced users. Davis (1989) also explained this phenomenon of *PU* mediating the effects of *PEOU* on *USAGE (*behavioral intention was not measured in his study). He found *PU* had a stronger relationship with *USAGE* than *PEOU* has with *USAGE* because users chose and adopted a technology or system primarily for the functions it could perform. The ease of use qualities are of only secondary importance. Ma (2003) observed that this could be the reason for *PEOU* to be antecedent for *PU*. Davis (1989) further suggested that a difficult-to-operate system could discourage adoption but any amount of ease of use without the usefulness would not help adoption either. This concept is particularly important as the usefulness of the system is far more important than ease of use in determining the user acceptance and adoption of a system. This suggests that physicians' perception of *usefulness of CPOE* is more important than their perceived e*ase of use of CPOE* for successful *CPOE adoption*. Davis (1989), Davis et al. (1989), Szajna (1996), and Ma (2003) observed that the ease of use effect on system usage is significant during the early stages of adoption, but after a considerable amount of user experience with the given system, the effect of ease of use on system usage diminishes and it acts primarily through usefulness. This observation fits with the data considering the 18 months of CPOE experience of Allina physicians and, as expected, ease of use did not have any significant effect on behavioral intention to use. Further, as explained earlier, the effect of *ease of use of CPOE* acts *indirectly* on *behavioral intention to use CPOE* through *usefulness of CPOE*. As noted above, the findings of this study are consistent with past TAM studies, as shown by the results that *ease of use of CPOE* acts on *behavioral intention to use CPOE* through *usefulness of CPOE.* This finding suggests that, although *ease of use of CPOE* is important, *usefulness of CPOE* is the one that ultimately decides successful adoption. Davis (1989) aptly describes that ease of use is overemphasized, by the designers of a system, over usefulness of a system, and implies that need not be the case. Therefore, during the training, physicians should be made aware of the usefulness or benefits to them and their practice. This means that physicians would be willing to tolerate ease of use problems as long as they perceive that CPOE is highly useful on the job. More importantly the benefits to physicians should be emphasized more than the benefits to the organization unless physicians have a real (monetary) stake in the organization such as holding stocks and shares, as practiced in many Fortune 500 companies.

Hypothesis 3 stated that perceived *usefulness of CPOE* will have a significant positive influence on *behavioral intention to use CPOE.* The results suggest that there is significant direct effect of *PU* on *behavioral intention to use CPOE* (*BI*). The results of the hypothesis 3 were presented in Tables 17, 18, and 19. Having the effect of *PEOU* on *BI* controlled, the direct effect *PU* on *BI* is significant with a β value of .648. Hypothesis 3 was supported as expected and consistent with many TAM studies (Davis, 1989; Davis, 1993; Davis et al., 1989, 1992; Money & Turner, 2004; Morris & Dillon, 1997). In fact, this hypothesis is supported in almost all TAM studies, suggesting that *usefulness* of technology or system in question is a strong determinant of behavioral intention to use and adopt the technology or system.

Gefen and Straub (2000) observed that while *PU* affected *IT-adoption*, *PEOU* has failed to do so directly in many TAM studies. Gefen at al. (2000), citing Davis et al.

(1989), stated that the intention to use is a product of the two salient beliefs PEOU and PU, and the effect of PEOU on PU, observed that in many TAM studies, was mainly through the mediating or intervening variable PU. Therefore, the ease of use of CPOE essentially affects *CPOE-adoption* through *usefulness of CPOE.* Further, the CPOE system was used by physicians for 18 months, and consistent with experienced users' beliefs about PEOU, there is no direct effect of *PEOU* on *BI* in this study. *PEOU,* in fact, acts an antecedent to *PU.* Therefore, the total causal effects of *PEOU* on *BI* is only indirect and operated primarily through the PU, which is (0.721*0.648) is 0.467, as shown in Figure 4. The effects analysis was carried out with their relative standardized regression coefficient (β) scores or weights, as carried out in Davis' 1993 study (Davis, 1993). The results suggest that *usefulness of CPOE* in addition to having direct positive influence on *behavioral intention to use CPOE*, *usefulness of CPOE* also mediated the effects of *ease of use of CPOE* on *behavioral intention to use CPOE*.

As discussed earlier, a system, however easy to use, will not be adopted if it does not offer the usefulness of the system on the job. Perceived usefulness is essentially concerned with the performance as a consequence of use (Davis, 1989). The CPOE system helps to achieve a better performance on the job, and hence this link of *usefulness of CPOE* and *behavioral intention to use CPOE* is stronger, and accounts for a much larger percentage of variance in *behavioral intention to use CPOE,* when compared with *PEOU*. To be specific, in this study, the total variance explained by *ease of use of CPOE* and *usefulness of CPOE* in *behavioral intention to use CPOE* is 40.5% (R^2=0.405) when both were regressed together. Tables 20, 21, and 22 also explain the individual variance of these two variables in behavioral intention to use CPOE. The effect of *usefulness of CPOE* on *behavioral intention to use* CPOE was controlled in step 1, and *ease of use of CPOE* was entered in step 2*. Ease of use of use of CPOE* neither increased variance in *behavioral intention to use* nor had any significant regression relationship with *behavioral intention to use CPOE,* as shown by the *change statistics* in Table 21 (Usefulness of CPOE: R^2=0.405, significant relationship. Ease of use of use of CPOE: R^2=0.000, insignificant relationship). This means that the *ease of use of CPOE* did not explain any variance in *behavioral intention to use CPOE*, and the variance of 40.5% in *behavioral intention to use CPOE* is fully explained by *usefulness of CPOE.*

Adams et al. (1992) cites Davis et al. (1989) and argues that the importance of usefulness over ease of use suggests that users adopt the system for the functions it performs for the users even though an extra effort is needed to use a highly functional system. Similarly, the strong effects of *usefulness of CPOE* on *behavioral intention to use CPOE* suggest that physicians could have perceived the CPOE system as a highly functional yet a difficult system to work with (Davis, 1989). This phenomenon is not uncommon in TAM studies. The flow of causality of ease of use → usefulness → behavioral intention to use also explains that ease of use is of secondary importance and directly concerned with *usefulness of CPOE* than with *behavioral intention to use CPOE* with the PEOU → BI link becoming insignificant with experienced users of CPOE system. The designers of CPOE need not panic as this is an expected finding in most of the technologies. This is one of the important findings and could be explained with a real life scenario.

Usefulness of CPOE is More Important than Ease of Use of CPOE

Consider changing a tire during a *cold winter day* in Minnesota. One would like to change the tire with bare hands, yet people in such situations wear gloves, as it is *useful* to protect the hands. Given a chance, the *intent* would not have been to use the gloves to change the tire because of the increased *effort of use* (ease of use); however, considering the *usefulness,* the gloves are used to change the tire. Therefore, the *ease of use* of using the gloves has no *direct* effect on *intent to use* the gloves, and here, *ease of use* acts through *usefulness* of gloves on the *intent to use* the gloves. Similarly, the *ease of use of CPOE* had no *direct* effect on *behavioral intention to use CPOE*, and acts primarily through *usefulness of CPOE* on *behavioral intention to use CPOE.* The *usefulness* of wearing the gloves outweighs the *ease of use* (effort of use) of wearing the gloves and changing the tire.

The results suggest that physicians are willing to tolerate less easy to use features of CPOE or willing to apply more effort of use to work with CPOE in their practice. Therefore, with experienced users of CPOE, the ease of use of CPOE → behavioral intention to use CPOE link becomes insignificant since the intent to use CPOE operates primarily through usefulness of CPOE. This might give a clue to the designers of a CPOE system as what they should aim to achieve more in usability of a CPOE; whether a system with more of ease of use of CPOE or usefulness of CPOE features. Undoubtedly, it is the usefulness of CPOE features that should be emphasized, however, it should not be interpreted that ease of use of CPOE should be neglected. After all, if we could have a pair of gloves that provided the same tactile sensations of skin most of us would likely welcome that in circumstances that require gloves.

Hypothesis 4

Hypothesis 4 stated that *behavioral intention to use CPOE* will have a significant positive influence on *CPOE usage.* There is a strong correlation of .780 between the BI and system USAGE, and the BI alone explains the variance of about 61% in system *USAGE.* Adams et al. (1992) observed that the intention-behavior link is stronger in experienced users, and the physicians who participated in this study had been using the CPOE system for more than a year-and-a-half, and this strong correlation between BI and USAGE is as expected. Adams et al. are of the opinion that experienced users also form their intentions gained from the continued use of a system. It is also important to note that this strong correlation between BI and USAGE comes with the caveat of common-method variance occurring from measuring self-reported usage and its determinants on a single questionnaire. Straub, Limayem, and Karahanna-Evaristo (1995) cautioned that studies using subjective self-reported measures for both independent variables and the dependent variable with minimally different measures could suffer from methods bias. The researchers further argued that measuring independent variables and dependent variables in the same instrument could induce hypothesis guessing, which is explained as a phenomenon in which subjects noting the trend of the questions asked would answer confirming with researcher's expectations. Straub, Limayem, and Karahanna-Evaristo, however, concluded that the relationships between TAM variables were not artifacts and the perceived effects are still valid and tenable. More importantly, with respect to this study, it is not suggested that the high correlation between BI and USAGE was inflated due to hypothesis guessing; however, this key information is provided here as a caution to the readers. Moreover, for this population of physicians, there was no other better and practical method than measuring all the variables in a single wave. Hypothesis 4 is strongly supported, which is consistent with TAM theory that posits that BI predicts the future user behavior (Adams et al., 1992; Davis et al., 1989, 1992; Morris & Dillon, 1997; Venkatesh & Davis, 2000).

Hypothesis 6

Hypothesis 6 stated that *perceived ease of use* and *usefulness of CPOE* will have a significant combined positive influence on *CPOE usage.* In some studies, there were no direct effects of *ease of use* and *usefulness* of system on *system usage* over and above *behavioral intention to use*, and the effects of *ease of use* and *usefulness* were only mediated via the *behavioral intention to use* construct on *system usage* (Davis et al., 1989, 1992). In six studies, researchers Davis (1989) and Adams et al. (1992) have observed significant *direct* effects of *usefulness* of system on system *usage* in over six technologies when the intention to use construct was not measured in these studies (Szajna, 1996). Szajna conducted a study with two models, pre-implementation and post-implementation, with behavioral intention to use as well as the system usage construct. In that study, Szajna observed significant *direct* effects of *perceived usefulness* on self-reported *usage* even with *behavioral intention to use* construct measured. Because of the mixed research findings, and since the present TAM study was conducted with the context (physician population in an organization)--target (CPOE system)--behavior (CPOE usage) scenario together, probably for the first time in a TAM study, the researcher wanted to see whether there are any *direct* effects of *usefulness of CPOE* on *CPOE USAGE.* It was also decided to study the direct effect of *ease of use of CPOE* on *CPOE USAGE*.

Lucas and Spitler (2000) did not include the measures of behavioral intention to use when the measurements were taken for the second time, but studied only the system usage in view of the fact that the workstation had been used for a long time, and the behavioral intention measures would not accurately depict the intentions to use the system. The researcher in the present study wanted to confirm Lucas and Spitler's view since the CPOE system had been used by physicians for over 18 months and wanted to learn whether *behavioral intentions to use CPOE* still predicted the *CPOE usage* and whether *ease of use of CPOE and usefulness of CPOE* had any direct effects over and above *behavioral intention to use CPOE* on *CPOE usage*. Thus hypothesis 6 was developed and tested.

The results were presented in Tables 26, 27, and 28. All three independent variables *PEOU, PU, and BI* were entered together with *USAGE* as the dependent variable. The results show that PEOU and PU did not have any significant effect on USAGE over and above BI. It was also explained with the help of Tables 29, 30, and 31 that BI mediated the effects of PU on USAGE. In several studies, system usage was measured after a lapse of 15 days, or so, of actual use of the system (Morris & Dillon, 1997; Venkatesh & Davis, 2000). However, in this study, CPOE USAGE was measured in a single wave with the other constructs. The standardized regression coefficient or β value of behavioral intention to use CPOE on CPOE USAGE obtained with *ease of use of CPOE* and *usefulness of CPOE* together in the regression equation is considered as the more appropriate value for the effect of *BI* on *USAGE.* The variance explained by PEOU, PU, and BI in USAGE is 63%, although it should be noted that both PEOU and PU did not have any influence on USAGE over BI. More importantly, the addition of two variables PEOU and PU in the regression model, as presented with the change statistics in Table 30, having controlled the effect of BI on USAGE, has shown an insignificant regression relationship of the two variables PEOU and PU with USAGE. It is safe to assume that the total variance of 63% is accounted by *behavioral intention to use CPOE* in *CPOE USAGE.*

Thus, hypothesis 6 is partially supported. There are only *indirect* causal effects of *ease of use of CPOE* and *usefulness of CPOE* on *CPOE usage.* The indirect effect of *ease of use of CPOE* on *CPOE usage* through *usefulness of CPOE* and *behavioral intention to use CPOE* is 0.328. The indirect effect of *usefulness of CPOE* on *CPOE usage* through *behavioral intention to use CPOE* is 0.449.

Interpretation of Means of the Four Constructs

The means and standard deviations are in acceptable range according to TAM studies with physician population. For example, Chau and Hu (2002) in their study investigating healthcare professionals' decisions to accept telemedicine technology, recorded the means (given within parenthesis) of the constructs PU (3.02), PEOU (3.20), and BI (3.23). Usage was not measured. It is important to note that all items of the constructs were measured using a seven-point Likert scale, and 4 is the mean or neutral value for all the constructs on such a scale. If those results are translated to the scale used in the present study, the means of the three constructs in Chau and Hu's study would be on the negative side of zero. In the present study, the means of all the four constructs are close to zero; the values of PEOU (-.651) and PU (-.486) are on the negative side of the zero and the values of BI (+.481) and USAGE (+.387) are on the positive side of the zero. One can see that the means of constructs recorded in this study are relatively better than Chau and Hu's study. The researchers, Chau and Hu, had only focused only on the explanatory power of the model rather than analyzing and interpreting the values of means of the constructs. However, interpreting the values of means of constructs of this study could be beneficial for the leaders who are involved with CPOE implementation.

The means of the four constructs close to zero may due to the several factors. Physicians, perhaps, would take fewer minutes to handwrite a prescription than they would take entering a prescription order through the system, and they would have considered handwritten prescriptions *easier* and more *useful* to *them.* They could have observed problems with workflows. Versel (2004) noted that physicians at Mount Sinai hospital felt that there were problems with clinical workflows when using CPOE. Koppel et al. (2005) also noted in their CPOE study that there were some human-machine interface and workflow problems that are not consistent with usual work behaviors. Physicians who are practicing for a long time may have liked to practice medicine in the way they were trained, as noted by Chau and Hu (2002). Physicians would have felt that that technology is distancing them from patients, as Magenau (1997) noted that like patients, physicians also want to retain the face-to-face interaction in the way they were trained, and that may be the reason for them not to have felt that CPOE that much useful. Moreover, physicians have unfavorable attitudes to implementing clinical information systems in their practice that are bound to interfere with their routine work (Anderson, 1997; Anderson & Aydin, 1997). Further, implementation of clinical information systems in medical practice also undermines the autonomy of physicians as their workflow and decision making are governed, instead, by the systems. Hospital administrators could potentially review and track omissions and commissions of physicians, which is a strong deterrent for physicians to use CPOE. CPOE sends alerts on medication and dosage issues, and physicians have to follow the system commands in order to proceed with orders. In addition to losing the autonomy, physicians could have also felt that expertise is questioned by the CPOE system. These reasons could be attributed to the low means being recorded in the study. Certainly, many hospital administrators would like to see more positive perceptions of the constructs. However, considering physicians perceptions of CPOE, and comparing with Chau and Hu's study, it may not be unusual to record means close to zero with physician populations. Nevertheless, after 18 months of CPOE adoption and use, the perceived usefulness and ease of use in particular remained low, giving hospital administrators reason to consider continued and periodic training to educate the physicians on CPOE's ease and utility.

Interpreting the Total Causal Effects of Perceived Usefulness and Ease of Use Constructs

The results of this study should be studied within the context of TAM. It is not a cause of concern for lack of *direct* effects of *ease of use of CPOE* on *behavioral intention to use CPOE.* The reasons for the lack of direct effect of *ease of use of CPOE* have been explained well and this was adequately compensated by the indirect effect, which forms the total causal effects, on *behavioral intention to use CPOE* that is strong with a path weight of 0.467. Similarly the indirect effect, which forms the total causal effects, of *ease of use of CPOE* on *CPOE USAGE* is also strong with a path weight of 0.328. These results suggest that ease of use of CPOE has a strong impact on CPOE adoption. Similarly, *usefulness of CPOE* has a very strong direct effect of 0.648 on *behavioral intention to use* as well as *indirect* effect, which forms the total causal effects, of 0.449 on CPOE usage, the surrogate for CPOE adoption. Further, *behavioral intention to use CPOE* explains 61% of variance in *CPOE USAGE,* which is consistent with TAM research suggesting that *behavioral intentions to use CPOE* predicts *CPOE USAGE* well (Venkatesh, & Davis, 2000).

The results of this study, physician adoption of CPOE, indicated that TAM was well supported and confirmed the fundamental premise of TAM that *perceived usefulness* and *perceived ease of use* are indeed the determinants of *behavioral intention to use* and ultimately on *user behavior* (Davis, 1989; Davis et al., 1989).

Lessons Learned and Future Directions

This TAM study has provided a baseline instrument to predict and explain physician acceptance of CPOE within an organizational context. In the future, this baseline model for CPOE acceptance may be expanded by adding external variables (factors) of organizational importance and studying how those factors influence physician acceptance and/or adoption of CPOE in an organization. As discussed in earlier chapters, the variables that are studied need to directly relate and contribute to organizational growth. Contributing to TAM theory is important; however, one should also take into account the applicability of the external variables from a practitioner's point of view. For example, Legris, Ingham, and Collerette (2003) noted that there was no clear pattern of the choice of external variables studied in various TAM studies. In 13 of the 22 TAM studies in their analysis, they found 37 different external variables were used. They are as follows: situational involvement, intrinsic development, prior use, argument of change, internal computing support, internal computing training, management support, external computing support, external computing training, perceived developer responsiveness, role with regard to technology, tenure in workforce, level of education, prior similar experiences, participation in training, quality perceived subjectiveness, compatibility, trainability, visibility, result demonstrability, tool functionality, tool experience, task technology fit characteristics, subjective norms, voluntariness, image, job relevance, output quality, result demonstrability, gender, experience, implementation gap, transitional support, effect of experience, computer self efficacy, objective usability, and direct experience. The remaining nine TAM studies did not evaluate any specific external variables.

As of January 2000, according to the Institute for Scientific Information's Social Science Citation Index, the two journal articles that introduced TAM, namely Davis

(1989) and Davis et al. (1989), were cited in 424 journal articles (Venkatesh & Davis, 2000). Except for a few studies, such as this one, most of TAM research would have studied the impact of external variables on the outcome. One could imagine how many external variables would have been studied now and added to TAM theory. Consider the number of variables used in all these studies, and how they could help a practitioner in studying the impact of external variables on the outcome. The forgoing observation is certainly not meant to be critical of any researcher, and with due respect to the all researchers' contribution to TAM studies, it is suggested that this cluttering of so many external variables is often due to uninhibited enthusiasm of contributing more to TAM research.

This scenario of studying more external variables could be compared with DeLone and McLean's (1992) observation when they reviewed 180 empirical studies to define a concrete dependent variable to measure the information system success. DeLone and McLean added that the different approaches by researchers not only made comparisons among studies difficult but also failed to define a concrete dependable variable to measure the information system success. Fortunately with TAM, we have two well-defined dependent variables in behavioral intention to use and system usage; however, the quest for finding the best combination of independent variables to the outcome in TAM studies is alarming, and it remains to be seen how they would help a practitioner in selecting the ideal combination of independent variables to study the outcome--meaningfully.

Therefore, the factors or external variables considered for further CPOE-TAM study should be judiciously selected that could be useful to the growth of the organization, which is beyond the scope of this study, to practitioners rather than to add more of theoretical perspectives to TAM. Judicial selection of external variables of importance to organization is necessary as there could be also an increased survey fatigue among physicians with many CPOE studies are being conducted now; the effective response rate among physicians could further go down resulting in questioning the applicability of the study to the larger world.

Two Proposed CPOE-TAM Instruments: Prediction and Adoption

As discussed earlier in detail, there were many TAM studies conducted with *behavioral intention to use* as the dependent variable without the system usage construct (Amoako-Gyampah & Salam, 2004; Brown et al., 2002; Chau & Hu, 2002; Hu et al., 1999), and *system usage* as the dependent variable ignoring the *behavioral intention to use* construct (Bajaj & Nidumolou, 1998; Igbaria et al., 1997; Karahanna & Straub, 1999; Leong & Hunag, 2002). In both these approaches, TAM was well validated. Considering the validity of TAM in both these two approaches in various settings, the same two approaches could be extended to physicians to study CPOE acceptance and adoption. For example, the CPOE instrument could be applied without the CPOE usage construct to study physician acceptance of CPOE. This could be ideally done immediately after the training to predict future acceptance of CPOE. On the other hand, after the physicians have started using CPOE, say after a lapse of one year, the second instrument without the behavioral intention to use construct could be used to study physician adoption of CPOE. As discussed earlier, these approaches are consistent with many TAM studies. Finally, the retest biases have not been reported when the same instrument is used again, as Venkatesh and Davis (2000) have used the same instrument in longitudinal studies. More importantly the revised CPOE instrument would have only 10 questions each permitting more questions added to study the impact of external variables on physician acceptance of CPOE or physician adoption of CPOE.

After analyzing the results and interpretation of the means of the constructs, it is felt that some physicians would have been using CPOE randomly, as and when they attend to patients at the Buffalo Hospital since they could be having only admitting privileges as opposed to working on a fulltime basis. It is possible that these physicians would have misunderstood the items especially when they refer to the frequency of use. Therefore, it is suggested to modify the TAM-CPOE instrument items in future research with respect to *behavioral intention to use CPOE* and *CPOE USAGE construct.* Items used in the present study for Behavioral Intention to Use CPOE and CPOE Usage Constructs are provided in Table 32 below. Table 33 presents proposed language for an amended instrument.

Table 32

Behavioral Intention to Use and CPOE Usage: Survey Items Used in the Present Study

Intentions to Use:	*Strongly Agree*			*Neutral*		*Strongly Disagree*	
I intend to use CPOE in my practice.	+3	+2	+1	0	-1	-2	-3
I intend to use CPOE frequently in my practice.	+3	+2	+1	0	-1	-2	-3
Usage:							
At the present time, I consider myself to be a very frequent user of CPOE.	+3	+2	+1	0	-1	-2	-3
I currently use CPOE continuously throughout my practice.	+3	+2	+1	0	-1	-2	-3

Table 33

Items Proposed for Behavioral Intention to Use CPOE and CPOE Usage Constructs

Intentions to Use (Assuming I have access to CPOE):	*Strongly Agree*			*Neutral*		*Strongly Disagree*	
I intend to use CPOE in my practice.	+3	+2	+1	0	-1	-2	-3
I intend to use CPOE frequently in my practice.	+3	+2	+1	0	-1	-2	-3
Usage (Assuming I have access to CPOE):							
Currently, I consider myself to be a very frequent user of CPOE.	+3	+2	+1	0	-1	-2	-3
I currently use CPOE continuously in my practice.	+3	+2	+1	0	-1	-2	-3

Using the words “Assuming I have to access to CPOE” is also consistent with Venkatesh and Davis’ (2000) study, where they used the behavioral intention to use question with "Assuming access to the system, I intend to use it." With respect to the Usage construct, the last item was not opinion-based as opposed to the rest of the items, which requested opinions of the survey respondents; however, these two usage constructs had been adapted from Davis et al. (1992) and Lucas and Spitler (2000). The researchers, Davis et al. and Lucas and Spitler, had used the *USAGE* construct questions in similar fashion consistent with the present study.

Additional research using these two approaches with added external variables (factors) of interest to organizations, and studying the impact of these factors on physician acceptance of CPOE and physician adoption of CPOE will help the practitioners develop new strategies for successful implementation, acceptance, and adoption of CPOE by physicians within an organizational context.

Choice of External Variables for CPOE-TAM Research – A Challenge

While suggesting to add external variables for future CPOE-TAM studies, the researcher was unable to find an ideal combination of external variables to study at this time, and it is worth recalling DeLone and McLean's (1992) observation, when analyzing 180 information system studies, that the dependent variable is the most important issue in information systems research, and defining one such dependent variable was elusive. Similarly, with respect to CPOE-TAM study, defining one such good combination of external variables is equally elusive for the researcher.

Conclusion

At this point it is worth recalling Morris and Dillon's (1997) observation that human-computer interaction (HCI) researchers typically focus on a system's *usability* as opposed to TAM that helps us to assess the *usefulness* of a system also. In fact, the researchers observed that *usefulness* of a system is often overlooked by HCI researchers. As we have seen in this study, the *usefulness of CPOE* is more important than the *ease of use of CPOE* in determining physician adoption of CPOE system.

There is a general opinion among information system researchers that physicians are reluctant to use technology. Chau and Hu (2002) observed that ''many physicians are not particularly technology literate, in spite of their general competence and learning capacity" (p. 298), and opined they are reluctant to use technology in workplace. If one goes by the history of technology developments and advancements, physicians have always embraced the technology with relative ease for the *larger interests of the world and society,* as long as they perceived the technology as *useful*. Consider the example of an electric screwdriver or forklift that mainly helps the professionals more of *ease of use* properties reducing injuries to their physiques, although it is *useful* to them (users) and their employers. On the other hand, consider the example of Laparoscopic Surgery of a diseased gall bladder. For purposes of the example, the gall bladder is just an organ connected to the liver, and tucked beneath the liver. The surgeon would use a few small incisions on a patient's abdomen, and a laparoscope, a tiny telescope, connected to a special camera is inserted, which transmits the magnified image of the internal organs to a video monitor, and with this *indirect guide*, the surgeon would guide his/her instruments through the tiny incisions to perform the surgery (American Academy of Family Physicians, 2005; The Society of American Gastrointestinal and Endoscopic Surgeons [SAGES], n.d). This surgery is opposed to the conventional method of opening the abdomen with a lengthy incision having the luxury of a large real estate to work with inside the abdomen. More importantly, this conventional procedure provides *invaluable direct* visual cues and tactile cues to the surgeon. Vision and touch complement each other, and absence of these cues is a *significant handicap* for surgeons (Azar, 1998). For patients, the costs of conventional surgery are high in many areas: longer hospital stay, longer post-operative period, and often, with potential complications not to mention about a major weakening of the abdominal wall (American Academy of Family Physicians, 2005; Beth Israel Deaconess Medical Center, n.d; SAGES, n.d). But surgeons do perform Laparoscopic surgery routinely, for the benefit of the larger cause of the society, and have *adapted well* to Laparoscopic surgery, albeit, giving due credit for more productivity with these procedures. The point to note here is at the time of *adoption of Laparoscopic surgery*, physicians were often troubled and handicapped by the indirect method of performing surgeries. Chau and Hu’s observation of physicians’ resistance to technology in the workplace could be easily questioned with this real-life example.

This example is presented here for the leaders, who would be implementing a CPOE system in future, to note that the *usefulness of CPOE* is more concerned with *adoption of CPOE* by physicians. This information is important as system designers and traditional HCI researchers focus more on *usability* of a system than on *usefulness* of the system (Morris & Dillon, 1997). It is also possible that HCI researchers would negatively view the lack of *direct* effects of *ease of use of CPOE* on *behavioral intention to use CPOE.* That is not the case with TAM. It is again reminded that any effect between constructs in this study needs to be analyzed as a whole and within the context of TAM. It is equally important to note that if adoption of Laparoscopic surgery, by applying TAM, among surgeons were studied those days, and going with the results of this study, it is *suggested*, that *ease of use of Laparoscope* would not have had any *direct* effects on *behavioral intention to use Laparoscope.* However, the effect of *ease of use of Laparoscope* would have acted, in all probability, indirectly on *behavioral intention to use and usage of Laparoscope*, through *usefulness of Laparoscope*.

While no one refutes employees' resistance to changes, lack of adoption of CPOE by physicians should not be termed as physicians' resistance to technology; rather the lack of adoption may be due to the fact the particular CPOE system was not perceived by physicians as *useful*. Therefore, the focus for leaders should be on *usefulness of CPOE* with a small leeway for physicians to endure difficulties in *ease of use of CPOE.* The results of this study show that CPOE system is perceived as relatively useful, and the behavioral intention to use strongly correlated with the *CPOE USAGE* predicting the CPOE use well, as explained earlier. The training sessions could well focus on the benefits of *usefulness of CPOE to physicians.* It does not mean that ease of use of CPOE is unimportant since any increase of ease of use by one unit will increase usefulness of CPOE by .721 units (β value) of usefulness of CPOE. Similarly, the respective path weights could be used by the leaders to assess and estimate how much *each ease of use of CPOE* and *usefulness of CPOE* would influence *behavioral intention to use CPOE* and *CPOE USAGE.*

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APPENDIX A

CPOE System – Physician Adoption Survey

CPOE System – Physician Adoption Survey

Instructions: Please do not write your name or other identifying marks on this survey. Your responses are anonymous so please provide your honest responses.

All items have a 7-point Likert scale ranging from *Strongly Agree to Strongly Disagree* with a *neutral* response as shown below.

Please **<u>circle</u>** the one most appropriate response to each question.

	Strongly Agree			*Neutral*			*Strongly Disagree*
Perceived Usefulness:							
Using CPOE improves my performance in my practice.	+3	+2	+1	0	-1	-2	-3
Using CPOE in my practice increases my productivity.	+3	+2	+1	0	-1	-2	-3
Using CPOE enhances my effectiveness in my practice.	+3	+2	+1	0	-1	-2	-3
I find CPOE to be useful in my practice.	+3	+2	+1	0	-1	-2	-3
Perceived Ease of Use:							
My interaction with CPOE is clear and understandable.	+3	+2	+1	0	-1	-2	-3
Interacting with CPOE does not require a lot of mental effort.	+3	+2	+1	0	-1	-2	-3
I find CPOE to be easy to use.	+3	+2	+1	0	-1	-2	-3
I find it easy to get CPOE to do what I want it to do.	+3	+2	+1	0	-1	-2	-3
Intentions to Use:							
I intend to use CPOE in my practice.	+3	+2	+1	0	-1	-2	-3
I intend to use CPOE frequently in my practice.	+3	+2	+1	0	-1	-2	-3
Usage:							
At the present time, I consider myself to be a very frequent user of CPOE.	+3	+2	+1	0	-1	-2	-3
I currently use CPOE continuously throughout my practice.	+3	+2	+1	0	-1	-2	-3

APPENDIX B

Cover Letter 1

Bowling Green State University
School of Leadership and Policy Studies

Division of Educational Administration and
Leadership Studies
510 Education Building
Bowling Green, Ohio 43403-0250
(419) 372-7377
FAX: (419) 372-8448
www.bgsu.edu/colleges/edhd/LPS

Date

Address

Dear Dr.________________,

You are invited to participate in a research study about your views on the Computerized Physician Order Entry (CPOE) System, also known as CPOE system or Order Entry System, which is being used by physicians to order tests, medications, treatments, etc. at Buffalo Hospital.

Please take a couple of minutes of your time to provide us your feedback on the CPOE system by answering the questions in the attached one-page survey titled "CPOE system – Physician Adoption Survey," that has only twelve simple questions. This survey aims to get your views on CPOE system. Opinions such as yours are of paramount importance to us in order to understand the physician adoption behavior of CPOE system.

Your responses are anonymous as no demographic information is requested in this survey. Further, we would like to assure you all individual responses will be kept confidential and stored in a locked file; only the researchers will have access to the records. In addition, the results will be reported or published only in aggregate and collectively. If you have any questions or concerns about the conduct of this study or your rights as a research participant, you may contact me at sachs@umn.edu (612-205-0757) or my doctoral dissertation chair at Bowling Green State University, Dr. Patrick Pauken, 505 Education Building, Bowling Green, Ohio 43403-0250 (paukenp@bgsu.edu, 419-372-2550).

After completing the one-page survey, please put the survey in the enclosed postage paid envelope and drop it in the U.S. mail.

Please accept our sincere thanks for your valuable responses, time and consideration.

Sincerely,

____

Sivan Sachidanandam, M. D.
NLM Fellow, Health Informatics
797, Mayo Memorial Building
University of Minnesota Medical School
University of Minnesota
Minneapolis, MN-55455

Enclosures.

APPENDIX C

Cover Letter 2

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Health Informatics
Laboratory Medicine and Pathology
Medical School

***777** Mayo Memorial Building*
420 Delaware St. S.E.
Mayo Mail Code 511
Minneapolis, Minnesota 55455

Phone: (612) 625-8440
Fax: (612) 625-7166
http://www.hinf.umn.edu

Date

Address

Dear Dr.________________,

My name is Sivan Sachidanandam. I am a physician and National Library of Medicine (NLM) Fellow at the division of Health Informatics, Laboratory Medicine and Pathology, University of Minnesota Medical School, Minneapolis, MN-55455.

As a fellow physician, I am interested in studying the physician adoption behavior of Computerized Physician Order Entry (CPOE) System, as stated in the cover letter, which would immensely benefit the entire physician community in healthcare delivery. This study has the potential to open up new frontiers to CPOE adoption among physicians, and I sincerely believe that you will participate in this study considering that there is dearth of research which addresses this situation.

Please find enclosed the letter from Ms. Kimberly Pederson, Vice President, Excellian, Allina Hospitals and Clinics in support of my research; and I am utilizing this research for my dissertation requirement of another doctoral degree. Please also find a small gift enclosed as a token of our appreciation for recipients' help with the survey.

I affirm that all responses will be kept confidential, and studied collectively as a group, and an executive summary of the study will be mailed to all recipients of the survey as soon as the study is completed. I request you to answer all twelve questions of the survey in order for the survey to be counted as a valid one for this study. Finally, I request you to mail your completed survey in 10 days which is greatly appreciated. If you have any questions please email me at sachs@umn.edu or call me at (612) 205-0757.

In conclusion, please permit me to thank you in advance for your assistance in this research.

Sincerely,

____

Sivan Sachidanandam, M. D.
NLM Fellow, Health Informatics
797, Mayo Memorial Building
University of Minnesota Medical School
University of Minnesota
Minneapolis, MN-55455

Enclosures.

APPENDIX D

Allina Access Letter

Excellian
225 S. 6th Street, Suite 1000
Minneapolis, MN 55402
612-775-2222
www.allina.com

ALLINA
Hospitals & Clinics

To Whom It May Concern:

Sivanarulselvan Sachidandandam, NLM Fellow in Health/Medical Informatics at the University of Minnesota, is granted access to work with Allina Hospitals and Clinics Excellian Project to complete course work pursuant to his degree.

Kimberly Pederson
Vice President, Excellian