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A Measure of Perceived Usefulness in the Pre-Implementation Stages of Healthcare Projects

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Information Technology success factors are interpreted as a cumulative measure of multi-dimensional constructs within a socio-technical model in an organizational structure and warrant organizational acceptance from pre-implementation to post-implementation periods. We use a theoretical model based on the Cognitive Dissonance Theory (CDT) to measure perceived usefulness of Information Technology activities. The constructs play an important role in setting initial user expectations before Information Technology activities are rolled out in organizations. In this study, we surveyed physicians to measure the perceived usefulness of a multi-million dollar healthcare project. The analysis shows that computer expertise has a direct, positive effect and an indirect mitigating effect on end-user concerns on perceived usefulness. Ease of use was also found to have a negative effect on perceived usefulness.

Keywords: *Pre-Implementation, IT Projects, Computer expertise, End user concerns, Perceived usefulness, Ease of use.*

Introduction

The Institute of Medicine landmark 1999 report, *To Err is Human-Building a Safer Health System*, estimated that medical errors kill up to 98,000 people every year at a cost of about $29 billion [1]. The staggering numbers reported and the fact that the majority of these errors were tied to preventable medication errors and adverse drug events (ADEs—such as allergic reactions

and dangerous drug-to-drug interactions) led to a follow-up studies that tried to confirm or deny the claims. Kaushal [2] found that the ordering phase of the medication process alone was generally considered to be the most perilous. Also, for adult patients 56% of medication errors could be attributed to the physician ordering phase, while that rate climbs to 75% for pediatric patients. The Congressional Budget Office estimated that there were 181,000 severe injuries attributable to medical negligence in 2003 [3]. A recent study [4] found that approximately 18 percent of patients in hospitals were injured during their stay, and most of the harms were severe. A major consequence of the 1999 report and all the other studies was that a lot more programs were put in place in hospitals and other health care facilities, programs aimed at reducing or even eliminating medical errors and improving patients' safety. One of the most used programs is the implementation of Computerized Physician Order Entry (CPOE) systems, which in combination with clinical Decision Support Systems (DSS) can greatly improve patient safety and possibly eliminate these errors. Empirical studies suggest that the implementation of the CPOE led to a decrease in medication error rate by 80% [5] one side, but also to the apparition of new types of errors [6].

From the information technology (IT) point of view, the success of CPOE can be determined almost exclusively by how readily the system is adopted by medical staff. The perceived usefulness of the system would certainly give a moral boost to the implementers of the project as well as enhance the future growth of this project throughout the healthcare industry. As the primary users, they can make or break the success of the IT investment by choosing to use, or not use, the new system.

This study is focused on predictive metrics (success factors) for successful implementation of the CPOE. The project will focus on identifying the likely early adopters (physicians) of the CPOE, understanding their expectations, i.e. their design parameters, and contrasting those expectations with their perceptions of the usefulness of the system. There are two major significant benefits to this study. The first and the foremost is the creation of a framework and model that will act as a step-stone to measure the usefulness of IT projects before their initiation. This empirical model was undertaken with the early adopters of the system and before the project actually began. Secondly, when the project is completed and in use, we plan to conduct another study to understand the post implementation success factors and plan to compare the results with the results from this study. To implement CPOE in a large scale, the healthcare industry needs to understand the initial expectations of the user community at large. The impact of technology as well as the socio-technology expectations of the users

will provide the implementers and the management a yardstick of the usefulness of the CPOE system. Furthermore, as costs of IT implementations escalate, a measure of usefulness is needed for IT implementation. Though, the measure of the usefulness has been cited in a number of research studies, current literature reflect only post IT implementations rather than pre implementations of IT.

Theoretical Model and Hypothesis Development

The Seddon structural model [7] and the DeLone and McLean structural model [8] each contained five variables (system quality, information quality, perceived usefulness, user satisfaction, and IT use). Both models exhibit reasonable fit with the collected data. The empirical findings are assessed in the broader theoretical context of the IT success literature, including the Technology Acceptance Model and the Theory of Planned Behavior. The results of Rai et al. [9] support DeLone and McLean's focus on integrated IT success models and their observation that IT success models need to be carefully specified in a given context. The Seddon model conceptually elaborates and clarifies aspects of the DeLone and McLean model, thereby effectively integrating core theoretical relationships espoused in the IT success literature. Their study also supports Seddon's three construct categories (system and information quality, general perceptual measures about net benefits about IS use, and IS behavior), as defining IT success and its impact on nature of IT use.

IT use has been explored using expectations of IT users. Realistic expectation of IT users, in particular has been found to influence the perceived benefits [10]. Zhang [11] found that consumer' expectations change over time, so no set of characteristics will stand the test of time. A number of unrealistic user expectations have been proposed especially the poor user interactions [12], and high expectations with low capabilities [13]. Petter [14] focused on software project and concluded that user involvement, leadership and trust were the most successful in managing user expectations. Self-efficacy perceptions have been found to influence decisions about what behaviors to undertake, emotional responses of the individual performing the behavior.

Aladwani [15] investigated the relationship among organizational actions, computer attitudes and end-user satisfaction in public organizations. He investigated the effects of management advocacy on computer attitudes and end-user satisfaction; lack of association among internal computing support, computer attitudes and end-user satisfaction.

In this study, we use Cognitive Dissonance Theory (CDT) to measure the perceived usefulness of IT projects prior to their implementations.

Cognitive Dissonance Theory

Expectations have been defined by researchers both in social psychology and organizational behavior [16, 17]. Two components of expectations surface up from these researches that include a future time perspective and a degree of uncertainty. Cognitive dissonance theory was used [18] to investigate as a theoretical basis. The theory of cognitive dissonance states that "individuals have a need for cognitive consistency." The theory also states that when an individual maintains two cognitive structures or ideas that are inconsistent with one another a psychological state of dissonance will occur. The individual will attempt to attain a state of consonance by changing one of the two cognitive structures [19]. Psychology literature suggests that IT users with high expectations of their performance should perform better than users with low expectations. The empirical evidence for this model is mixed. However, marketing literature using the same model implies that users with unrealistically high expectations that have been disconfirmed will have higher perceptions about the IT than users who had realistic expectations. Moreover, users with unrealistically low expectations that are disconfirmed will have lower perceptions than those with realistic expectations [20, 21, 22].

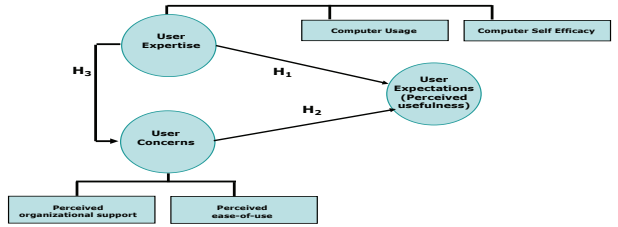
In this study we integrate the fundamental concepts of CDT and IT adoption literature to examine how self-efficacy and computer usage influences physicians' attitudes towards both the usefulness of and concerns about CPOE. CDT stresses that self-efficacy begets confidence and willingness to master new technologies. Is it also true that computer expertise will have a positive effect on perceived and expected usefulness? Moreover, does computer expertise mitigate undesirable trepidation for new technology, including fears about ease of use and organizational support? In other words, do the cognitive forces at work in CDT (namely, self-efficacy) also affect the critical factors of usefulness, ease of use, and organizational support?

We know from CDT that the physicians with higher computer expertise will have higher outcome expectations. This study attempts to link such outcome expectations to specific notions of usefulness about the new IT projects. Clearly, outcome expectations are not wholly about the usefulness of the IT, but physician satisfaction with CPOE will be determined mostly by how useful CPOE is perceived to be for their practice of medicine. Therefore, outcome expectations

are really a proxy for expectations for the usefulness of CPOE. Borrowing from CDT, this study postulates that users with high computer expertise will have high expectations for the usefulness of the new IT. We already know from IT adoption literature that perceived usefulness is critical to successful IT outcomes. Furthermore, we know that aspects of an IT, like ease of use and organizational support, can either help or hinder perceptions of IT usefulness. IT adoption literature suggests that an IT project that is easy to use will allow users to be more productive and to give them the opportunity to appreciate the systems usefulness. The corollary to this is that users will be turned-off by systems that are too difficult to use and they will not recognize the benefits of the system's usefulness. As such, this study also attempts to establish a link between computer expertise and end-user concerns about ease of use and organizational support. It is postulated that the same cognitive affects that allow expert users to have higher expectations for perceived usefulness cause these users to have simultaneously lower concerns about ease of use and organizational support. If this is true, then computer expertise can be shown to have both a direct and indirect effects on perceived usefulness.

Hypothesis Development

This study is different from most of the current and past literature in that most other studies have an ex-post dependant variable, i.e. system usage, user satisfaction, performance, or at the very least usage intentions. Instead, this study is predictive, and the first part of a two part study (the second part will link predictions to usage). This study looks at aspects that influence, both positively and negatively, usefulness—therefore examining indirectly influences on acceptance. Our proposed model is illustrated in Figure 1.



Hypothesis	Supporting Reference
H1: The higher the user's IT expertise, the higher his/her perceived expectations of IT projects	Bandura (77), Compeau (99), Betz (81), Stumpf (87), Lyytinen (88), Agarwal (98)
H2: The higher the user's concerns, the lower his/her perceived expectations of IT projects	Szajna (93), Sanders (84), Aladwani (2002)
H3: The higher the user's IT expertise, the lower his/her concerns about the project	Compeau (95), Davis (89), Hill (87), Thompson (91)

Figure 1: Proposed Model

Here, perceived usefulness is taken as a given predictor of technology acceptance and perceived IT expertise is proposed to have a direct effect on perceived usefulness and an indirect effect on various perceived IT concerns. Also, perceived IT concerns are proposed to have an indirect effect on perceived usefulness.

As discussed in the CDT literature, IT self-efficacy and prior IT experience have been shown to have a positive effect on perceived usefulness. Therefore, it is proposed that the higher the user's IT expertise, the higher his/her perceived usefulness of IT projects.

H1: The higher the user's IT expertise, the higher his/her perceived expectations of IT projects.

Cognitive dissonance theory also suggests that low user expectations for IT will lead to low perceived satisfaction. Moreover, anxiety about to ease of use and anxiety about factors that mitigate ease of use, such as management advocacy and end user training/support, have a negative effect on perceived usefulness. Hence, it is proposed that the higher the user's concerns, the lower his/her perceived usefulness of IT projects.

H2: The higher the users' concerns, the lower his/her perceived usefulness of IT projects.

Finally, self-efficacy and prior user experience mitigate against user concerns and improve ease of use. Hence, the higher the user's IT expertise, the lower his/her perceived usefulness of IT projects

H3: The higher the user's IT expertise, the lower his/her concerns of IT projects.

Computer Self-efficacy: Perceived self-efficacy is closely linked to an individual's willingness to adopt new technologies. The authors of this study anticipate that physicians with greater comfort with computers will adopt CPOE quickly. It is anticipated that confident computer users will have higher expectations for CPOE usefulness and lower concerns regarding ease of use.

Computer Usage: The survey questions were designed to identify the extent to which physicians use the computer. The CPOE selected by the hospitals in this study uses a web-based user interface, therefore it is anticipated that physicians with greater prior computer usage will be more successful with the CPOE—not to mention more ready adopters of the new system.

Perceived Usefulness: The survey questions are based on the technology acceptance model literature, but are customized for the CPOE domain. These questions are designed to measure the extent to which physicians expect CPOE

to help them practice medicine. Specifically, it is unclear if CPOE will help physicians practice medicine more efficiently, and several of these questions are designed to measure perceptions in this regard. Moreover, CPOE is unanimously expected to help make the practice of medicine more safe for patients, and several questions are designed to measure the strength of physician expectations regarding improved patient safety.

Perceived Ease of Use: Many physicians are concerned that CPOE will make it more difficult and time consuming for them to practice medicine. These questions are drawn largely from the technology acceptance model literature and, as with the perceived usefulness questions, these questions have been modified for the domain. They address specific ease of use issues identified in the preliminary physician focus group discussions.

Perceived Organizational Support: Several studies have suggested that perceived organizational support for IT projects can influence end users' expectations and concerns for the outcome of the project. These questions were derived from the preliminary physician focus studies and are designed to measure the physicians' perceptions regarding the hospitals' support for the CPOE project. Appendix 1 shows the study constructs and the survey questions that guided the development of the specific measures.

Study Design and Results

Data for this study were collected using a survey administered to the active medical staffs of three hospitals in north-central Indiana. The hospitals are part of an integrated medical delivery system. The physicians surveyed included both employed and independent physicians.

The survey was mailed to 100% of the active medical staff of all three hospitals, or 510 physicians. About 220 physicians responded to the survey. Before the survey was mailed, the mailing list was culled to remove duplicate names of physicians on staff at more than one hospital. The original mailing included a letter (encouraging participation in the survey) from several well respected physician administrators from each of the three hospitals, along with a physician authored article about CPOE. The surveys were printed with the recipient physician's name on the survey. About two weeks later a second mailing was sent to all of the physicians with another letter encouraging their participation. The survey questions were derived base on the aforementioned survey of the IT literature survey, tempered for domain specificity through a series of preliminary

physician focus studies. The survey questions were scored on a five-point Likert scale.

Before analyzing the results of the study, it is first necessary to explore the internal consistency or reliability of the measures within each construct. Table 1 shows the reliability coefficients, Cronbach's alpha, for each of the constructs.

Table 1: Assessment of Internal Reliability

Construct	Cronbach's Alpha
Computer Self-efficacy	0.9
Computer Usage	0.6
Perceived Usefulness	0.9
Perceived Ease of Use	0.82
Perceived Organizational Support	0.74

Cronbach's alpha for computer usage and perceived organizational support were 0.60 and 0.74, respectively, indicating an acceptable degree of internal reliability and consistency for multi-item scales; the other constructs range from 0.82 to 0.90, indicating a high degree of internal reliability [37]. The purpose of factor analysis was to reduce the observed measures in each construct down to a more manageable number of factors—ideally, the observed measures in each construct should yield a single factor. Using a communality cut-off of 0.50, it was found that all of the observed variables, in each construct, loaded to the factor solution. Communalities represent the proportion of the variance in the original variables that is accounted for by the factor solution.

The factor solution should explain at least half of each original variable's variance, so the communality value for each variable should be 0.50 or higher. Moreover, using an eigenvalue cut-off of 1, each of the constructs did indeed extract to a single factor. Eigenvalues describe the variance in a set of variables explained by a factor. The factor scores for each observed case (i.e. each physician survey) was saved to be used in subsequent linear regression analysis. The scores, which have a data set mean of 0, were scanned for outlier cases, i.e. cases whose factor scores have an absolute value of more than 3. No outliers were found for any of the constructs.

Table 2 shows the total variance explained by the component for each construct. The descriptive statistics and correlations between variables employed in this study are presented in Table 3. Several significant correlations between variables can be observed.

Table 2: Total Variance Explained by Construct Components

Construct	Total Variance Explained
Computer Self-efficacy	73.06%
Computer Usage	71.49%
Perceived Usefulness	67.44%
Perceived Ease of Use	65.28%
Perceived Organizational Support	65.85%

Table 3: Correlation Matrix and Descriptive Statistics for Constructs

Construct	Mean	Std. Deviation	SE	USG	EA	ORG
Computer Self-efficacy (SE)	3.6675	0.9809				
Computer Usage (USG)	2.7165	0.7776	0.562**			
Perceived Ease of Use (EA)	3.5259	0.9057	-0.242**	-0.169*		
Perceived Organizational Support (ORG)	3.4533	0.981	-0.271**	-0.191*	0.545**	
Perceived Usefulness (USE)	3.3953	0.9696	0.31**	0.327**	-0.222**	-0.136
** Correlation is significant at the 0.01 level (2-tailed).						
* Correlation is significant at the 0.05 level (2-tailed).						

User's computer expertise was found to be positively correlated with perceived usefulness. In the model, computer expertise is composed of two constructs: computer self-efficacy and computer usage. Individually, both of these constructs were found to have a positive effect on perceived usefulness. While, both perceived ease of use and perceived organizational support were found to be negatively correlated with perceived usefulness, only the correlation between ease of use and perceived usefulness was found to be statistically significant at 1% level of significance.

Table 4 shows the standardized betas, R square values, and significance levels for the effects of our constructs on perceived usefulness.

Table 4: Effects of Constructs

	Perceived usefulness		
	Standardized Beta	R square	Significance
Computer Self-efficacy	0.348	0.116	0.001
Computer Usage	0.35	0.123	0.001
Perceived Ease of Use	-0.2	0.039	0.009
Perceived Organizational Support	-0.086	0.007	0.261
User Expertise	0.237	0.152	0.001
User Concerns	-0.15	0.031	0.072

The standardized betas for the first two constructs (0.348 and 0.35) confirm that the computer expertise constructs have a positive effect on perceived usefulness. The R square values indicate that individually, both self-efficacy and computer usage explain approximately 12% of the variation of the physicians' perceived usefulness of CPOE. In their combined construct, computer expertise, computer self-efficacy and computer usage explain more than 15% of the variation in perceived usefulness. At less than 0.001, the significance values indicate that the effect of the computer expertise constructs on perceived usefulness is unlikely to be the result of chance.

The standardized betas for user concern constructs (-0.2 and -0.086) confirm that each construct has a negative relationship to perceived usefulness. However, the R square value for each construct indicates that very little of the variation in perceived usefulness is explained by the end-user concerns constructs. The p-value for perceived ease of use is significant at the 0.05 level, but organizational support was not found to have a significant effect on perceived usefulness. The combined construct, end-user concerns, was also not found to be a significant predictor of perceived usefulness.

Table 5 shows the standardized betas, R square values, and significance levels for the effects of our user expertise on user concerns.

Table 5: Effects of User Expertise on User Concerns

	Standardized Beta	R square	Significance
Computer Self-efficacy	-0.224	0.05	0.002
Computer Usage	-0.125	0.016	0.08
User Expertise	-0.215	0.05	0.008

Users' computer expertise was found to have a mitigating, or negative, effect on end-user concerns. As indicated by the standardized beta, both components of the computer expertise construct were found to have negative effects on end-user concerns. The R square for each component suggests that a small amount of the variation in end-user concerns is explained by each of the individual computer expertise components. However, as revealed by the p-score for each component, only computer self-efficacy was found to have a significant effect on end-user concerns, at the 0.05 significance level. Combining computer self-efficacy and computer usage has little effect on the strength, direction, or significance of self-efficacy as a stand alone construct.

Discussion

The first hypothesis tested by this study was the proposal that the higher the user's IT expertise, the higher his/her perceived usefulness for IT projects. This proposal in based on CDT that suggests that users with strong computer self-efficacy will have the perseverance to overcome obstacles along the path of adopting a new IT, such as CPOE. Moreover, CDT implies that users with high computer expertise will have high outcome expectations; these outcome expectations contribute to better actual outcomes due to the cognitive balancing users experience if such expectations are disconfirmed. But what are these expectations? This study assumes that user expectations focus on usefulness and ease of use for the new IT, and organizational support for the new system. We find that users with some computer expertise have high expectations for a new IT system to the extent we can assume these expectations are related to usefulness, ease of use, and organizational support. In other words, computer expertise supports expectations of usefulness, ease of use, and organizational support. This study found support for this hypothesis. Both components of the computer expertise construct had a positive effect on perceptions of usefulness. Both computer self-efficacy and computer usage explained about 12% of the variation in perceived usefulness. While not a lot of the variation is explained, the result is highly statistically significant ($p < 0.001$). Furthermore, when computer self-efficacy and computer usage are combined into a single construct, computer expertise, over 15% of the variation in perceived usefulness is explained. Again, this result is statistically significant at the $p < 0.001$ level.

CDT implies that if end users have trepidations about a new IT and if they are concerned about its ease of use or organizational support for the project, they are less likely to adopt the new IT. From CDT we know that computer-phoebes will have lower expectations of their own abilities with a new IT project. Cognitive machinations will almost inevitably lead these users to have poorer outcomes because they expect to do poorly. Technology acceptance theories suggest that perceived ease of use is a significant predictor of IT acceptance. Perhaps from these models we can presume that end user concerns have a direct negative effect on perceived usefulness and, therefore, an indirect negative effect on technology acceptance. The second hypothesis asserted by this study was that end user concerns about ease of use and organizational support have a negative effect on perceived usefulness. This study found some support for this hypothesis. It was found that both components of the end-user concerns construct, ease of use and

organizational support, had a negative effect on perceived usefulness. However, these effects were very small and only perceived ease of use had a statistically significant effect on perceived usefulness. Perceived ease of use explained nearly 4% of the variation in perceived usefulness (p = .009). In its combined form, the end-user concerns construct did not have a significant effect on perceived usefulness.

Finally, this study tested the notion that computer expertise mitigates end user concerns. This proposition assumes that the CDT forces that lead expert users to have better outcomes will also result in them having lower concerns about the new IT. If true, perhaps it is possible to infer that by mitigating end user concerns, computer expertise has and an additional indirect effect (above and beyond its direct effect) on technology acceptance (again, the direct effect is that computer expertise leads to expectations of usefulness, users are reluctant to have those perceptions disconfirmed, and usefulness leads to technology acceptance).

This study found some support for the hypothesis that computer expertise mitigates end-user concerns. The component construct of computer self-efficacy was found to explain 5% of the variation in end-user concerns (p = 0.002). However, the component computer usage was not found to be significant. The combined construct, computer expertise, was found to explain 5% of the variation in end-user concerns (p = 0.008).

In conclusion, our study found support for the hypotheses that computer expertise leads to higher perceived usefulness for IT projects. Physicians with higher computer self-efficacy and computer usage had higher expectations for the usefulness of CPOE. This study also found moderate support for the hypothesis that end user concerns about IT projects have a negative effect on perceived usefulness. Physician concerns about ease of use were found to have an effect on perceived usefulness, while concerns about organizational support were not to have a significant effect on perceived usefulness. And finally, our study also found some support for the hypothesis that computer expertise has a mitigating effect on end user concerns. Computer self-efficacy was found to have a negative effect on end user concerns, while computer usage was not found to have an effect.

Summary and Contribution

The perceived usefulness of an IT project before its implementation and its relationship to the user community are not well understood. In this research we present a set of constructs and a methodology to understand and support user concerns and user expectations. We use the data collected from the prospective

users of the IT system to study this methodology. The users' concerns and expertise contribute to the overall expectations and the perceived usefulness of the IT project.

The study makes the following contributions. We present a theoretical perspective in Information Technology using the Cognitive Dissonance Theory based on previous work in social psychology and organizational behavior. Second, we have integrated the Cognitive Dissonance Theory with concepts from the IT adoption models to investigate the effects on user expectations. To the best of our knowledge, this is the one of the few studies to do so. Third, we have studied the effects of user expectations before the IT implementation. Fourth, we have used the survey from physicians who are the actual users with real concerns to speak their minds on the usefulness of a new multi-million project. This is one of the few studies to engage physicians to study the performance of a new healthcare project.

This research is specific to the healthcare industry. A principal limitation of this study is the generalized view of the reported findings. This is a first part of a two-part study; the second part is aimed at understanding the post implementation success factors to determine the value of this IT project. We believe that the theoretical framework in this study can be extended to understand the user expectations of other industries as well. We believe that this measure will lead both the academicians and practitioners another method to evaluate IT success factors.

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Appendix 1: Constructs and Measures (Survey Questions)

Computer Self-efficacy
1. Please rate your comfort level with computers in general.
2. Please rate your comfort level with handheld computers/PDAs.
3. I am very comfortable sending and receiving email.
4. I am very comfortable managing email folders and attaching files to emails.
5. I am very comfortable using a word processing or spreadsheet program, such as Microsoft Word or Excel.
Computer Usage
1. During an average week, how many hours do you use the computer for activities not related to the practice of medicine?
2. During an average week, how many hours do you use the computer for activities related to the practice of medicine?
Perceived Usefulness
1. Reducing the number of telephone calls from pharmacists seeking clarification on verbal orders or due to illegible handwriting, erroneous orders, or incomplete orders.
2. Reducing the number of adverse drug events (ADEs) due to incorrect doses, drug-drug interactions, or allergic reactions, etc.
3. Improving the turnaround time for inpatient pharmacy, lab, and radiology orders.
4. Reducing the difficulty in tracking down the results of diagnostic tests.
5. Improving the efficiency of making rounds in the hospital.
6. Reducing the number of visits you make to the hospital or bedside because you can access patient information from off-site, such as from home or from your office.
Perceived Ease of Use
1. The amount of time required to do computerized order entry versus writing orders manually.
2. The ease of use and user-friendliness of the software.
3. The number of false alarms generated during the order entry process.
4. The availability of predefined order sets.
Perceived Organizational Support
1. The availability of around-the-clock technical support.
2. Availability of end-user training.
3. Support from the hospital's Executive Administration.