Investigating the Mediating Effect of the Accuracy of Information in the Relationship Between IT and the Quality of Healthcare in Hospitals

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Abstract

The safety and quality of healthcare is of great concern in the United States. Hospital administrators, healthcare providers, and healthcare delivery systems all strive to provide safe and quality care for patients in complex environments. Many have suggested that information technology (IT) may reduce medical errors and increase the quality of healthcare in healthcare organizations. This study investigates how clinical IT may improve the quality of healthcare through its effect on the perceived accuracy of information for clinical decision making available to nurses in hospitals. The study found evidence that IT does positively affect the perceived accuracy of information that, in turn, affects the quality of healthcare in hospitals. Implications of these findings are discussed.

1. Introduction

The safety and quality of healthcare is of great concern in the United States. Hospital administrators, healthcare providers, and healthcare delivery systems all strive to provide safe and quality care for patients in complex environments. However, it has been reported that thousands of hospitalized patients are frequently harmed by the very care that is intended to facilitate their well-being [3]. The Institute of Medicine (IOM) reports, To Err is Human and Crossing the Quality Chasm [9], deduced that each year many Americans are harmed as a result of adverse events that occur during hospitalizations. Specifically, the IOM reports that 44,000 to 98,000 deaths occur each year because of medical errors [3]. These medical errors are the eighth leading cause of death in the U.S. It is estimated that the annual cost of medical errors is 17 to 29 billion dollars annually.

While medical errors may occur for many different reasons, some possible causes of these adverse events are work demands [19], improper monitoring of patients, and prescribing errors [26]. Prescribing errors are the most common adverse medical events, and researchers have indicated that they may cause 32 to 64% of medical errors [16].

The healthcare industry today is information-intensive [27]. The patient medical record is a document and repository of pertinent information for management and care of the patient. The patient medical record also includes documentation of clinical treatment, plans, and observations [15]. The medical record is frequently updated with treatment history and clinical experiences to provide information for the course of treatments and decision support for clinicians in caring for medical patients [45].

The conventional paper-based medical record has been in existence for several centuries [38]. The paper records began as a personal clinical notebook containing pertinent details to remind healthcare providers of the care experiences of individual patients. These notebooks would frequently be used for dialogue with colleagues and were free from government and regulatory agencies’ authority over what information was required in the record [35] [41].

Today, paper-based medical records are used in more than 85% of healthcare organizations [23]. This data-rich document is a major source of information for daily healthcare delivery. It includes healthcare providers’ handwritten information about patients’ diagnoses, assessments, therapeutic strategies, and treatment histories [28]. Advantages of the paper-based medical record are that it is portable to the bedside, it does not crash as computers do, and it allows the provider the freedom to record data in his or her own words.

On the other hand, the paper-based medical record has many limitations. These medical records are frequently wrought with inefficiencies, such as illegible handwriting and missing information, as
well as contain unorganized and inaccessible documentation, which may cause difficulty in assuring quality of care [45]. These records frequently become bulky or expand into multiple volumes over time, which may cause important information to be overlooked [39]. These barriers could encumber quality of care.

The problems associated with paper-based medical records have led practitioners and researchers to investigate converting these paper-based records to computer-based records [45]. In many industries outside of healthcare, information technology (IT) has been associated with positive outcomes [43]. IT has also been associated with greater efficiency and lower costs [11], more timely outcomes and greater quality [5], greater productivity [8] [10], better decision making [33], and better coordination and communication [36]. The positive effects of IT in other industries have bolstered expectations that IT may also have some of these effects in the healthcare industry [45].

Case studies have produced information about some potential advantages of clinical IT. These findings need to be further investigated to increase generalizability. One documented advantage of clinical IT is the elimination of handwritten records that are difficult to read. Other advantages include easier access to patient information and data from other departments (laboratory, pharmacy, radiology, consultations, etc.), easier access to information needed for clinical decision support [27] [28], and frequently, the ability to interface and integrate among clinical technology applications [4]. These advantages may lead to enhanced patient safety and quality of care. This study investigates how clinical IT may improve the quality of healthcare through its effect on the perceived accuracy of information for decision making available to nurses in hospitals. The model for this study is shown in Figure 1. In the model, the level of IT implementation affects the perceived accuracy of information for decision making. Perceived accuracy of information, in turn, affects the quality of healthcare in the hospitals in the sample.

![Figure 1: The Conceptual Model for the Study](image)

2. Background

Clinical IT in healthcare organizations consists of several technology applications to provide assistance and information to clinical healthcare personnel such as nurses in hospitals. These clinical IT applications include clinical data repository (CDR), clinical decision support systems (CDSS),
computerized practitioner order entry (CPOE), laboratory information systems (LIS), order entry (OE), pharmacy management systems (PMS), physician documentation (PD), and radiology information systems (RIS). The definitions for these clinical IT applications are given in Table 1. These definitions come from the HIMSSAnalytics Database. HIMSSAnalytics is an organization that “collects and analyzes healthcare organization data relating to IT processes and environments, products, IS department compositions, and other IT related information” (from HIMSSAnalytics Website [22]). This study uses IT implementation data from the HIMSSAnalytics database as will be explained later in the Methodology section.

<table>
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<tr>
<th>Table 1</th>
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<tr>
<td><strong>Definitions for Clinical IT Applications</strong></td>
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<tr>
<td>Clinical Data Repository (CDR)</td>
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<tr>
<td>Clinical Decision Support Systems (CDSS)</td>
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<tr>
<td>Computerized Practitioner Order Entry (CPOE)</td>
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<tr>
<td>Laboratory Information Systems (LIS)</td>
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<tr>
<td>Nursing Documentation (ND)</td>
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<td>Order Entry (OE) (Includes Order Communications)</td>
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<td>Pharmacy Management System (PMS)</td>
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<tr>
<td>Physician Documentation (PD)</td>
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<td>Radiology Information System (RIS)</td>
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(HIMSSAnalytics, 2009) [22]

The concept of information quality is becoming more important as information becomes the very lifeblood of organizations today. The operational, tactical, and strategic performance of organizations is tied directly to the quality of their information [18]. Poor information quality can wreak havoc in organizations by resulting in customer dissatisfaction, increased costs, reduced levels in the effectiveness of decision making, and a diminished ability to plan, implement, and execute organizational strategies [37]. For example, inaccurate information may result in customers getting charged for products or services that they did not purchase. Products might be shipped to the wrong addresses. Human resources departments could spend enormous amounts of time correcting errors in the personnel files of their companies’ employees. Poor information quality may be the single biggest obstacle to developing sound business strategies [37]. In an industry like healthcare, poor information quality can literally be the difference between life and death. Accurate information is thought to be a key in providing the very best healthcare possible. Accuracy in this study is defined as the degree to which information for decision making is correct, unambiguous, valid, free of errors, and consistent [34].
Building a safer system with quality healthcare is the goal of healthcare organizations and has become paramount in almost every hospital in the U.S. within the past two decades. Governmental agencies such as the IOM, consumer groups such as The Leapfrog Group, and healthcare groups such as the Joint Commission on Healthcare Organizations (JCAHO) have become very involved in the pursuit of quality healthcare [1] [12] [24] [29]. With increased awareness of the need for quality healthcare, it is important for healthcare providers to manage a plethora of information and knowledge in order to provide safe, quality healthcare.

In the U.S., registered nurses (RNs) comprise the largest profession in healthcare with more than 2.5 million jobs. Fifty-nine percent of RNs work in hospitals, delivering more than 70% of actual service delivery in hospitals [2] [42]. As providers of the greater part of healthcare services in a variety of settings and their extensive training in theory and practice, RNs are in a position to appreciate the quality of care that patients receive. Exploring the perceptions of quality of care in this population is fundamental to understanding how the quality of information impacts quality of healthcare in hospitals. In this study, three facets of healthcare quality are investigated. These are assurance, collaboration, and safety. Assurance is the degree to which nurses are knowledgeable, dependable, and reliable in delivering healthcare services to patients. Collaboration is the degree to which the nurses are able to communicate with other healthcare workers and work in a cohesive team to deliver healthcare. Safety is the degree to which nurses provide an accident and error free environment in providing healthcare to patients.

3. Hypotheses

This study examines the relationship of levels of IT implementation and the perceived accuracy of information for clinical decision making in hospitals from the perceptions of chief nursing officers (CNOs). The first relationship in the research model will examine the link between the level of IT implementation and perceived accuracy of information. There are several reasons to explore how the level of IT implementation may be associated with the perceived accuracy of information. First, there is previous evidence that the implementation of information systems leads to better overall information quality in many organizations [14]. The standardization and integration of processes resulting from IT were found to be associated with such positive organizational traits such as communication, consensus, coordination, and measurability [47]. These are organizational traits that have been found to increase the perceived accuracy of information in all types of organizations [17].

There is evidence from case studies in the healthcare industry that IT can improve the perceived accuracy of information. Embi and his colleagues [15] found improved quality of information in the implementation of a computerized provider documentation system. They measured quality of information by the availability of documentation, improved legibility and accuracy, and better accessibility. Mekhjian and his colleagues [31] found that a computerized provider order entry (CPOE) system had substantial impact on the quality of information in an academic medical center. The CPOE virtually eliminated all physician and nursing transcription errors. The quality of information was measured in this study by Mekhjian and his colleagues [31] by timeliness and reduction of medical errors. These studies, along with the previous evidence, point strongly to a relationship between the level of IT implementation and the perceived accuracy of information in hospitals. Therefore, the first hypothesis is:

**H1: The level of clinical IT implementation is positively related to the perceived accuracy of information for clinical decision making in hospitals.**

Inaccurate information is likely related to poor task execution in work processes like patient care [37]. Flawed information quality in hospitals can lead to all types of errors in patient care. Patients may be given the wrong medications or the wrong dosage of the right medications, may be switched with other patients in the hospitals, or may receive the wrong surgeries, among other things, when the perceived accuracy of information is poor.

The problems resulting from faulty information have been proliferated with the recent changes in healthcare. In the past, the primary physician was at the top of the medical pyramid, and most medical decisions were made through that physician. In today’s medical environment, medical care is mainly dispensed by multidisciplinary teams of clinicians and non-clinicians who must provide comprehensive and coordinated care to their patients [44]. In such an environment, the caregivers must depend on information they have on hand about the patients to accurately and quickly deliver their respective treatment. When the perceived accuracy of the information is poor, the caregivers are likely to wrongly diagnose the complaint and to deliver an improper treatment to a patient. It has been reported that nearly half of the serious medication errors are a direct result of medical caregivers not having
sufficient accuracy of information [6]. Of course, on the other hand, the better the data quality, the more likely the problem is diagnosed accurately and the proper treatment is administered [44].

Tucker [46] completed one study examining the impact of operational failures on healthcare quality. Operational failures in her study included disruptions or errors in the supply of necessary materials and errors in information available to employees. She found that the operational failures in her study contributed to delays in patient care and other difficulties in the overall quality of care. One of the most serious problems encountered was patients being subjected to unnecessary medical procedures. This study, along with other evidence presented here, leads to the following hypotheses:

**H2: There is a positive relationship between the perceived accuracy of information for clinical decision making and the quality of healthcare in hospitals.**

### 4. Methodology

A five point Likert questionnaire was developed to collect data from CNOs in single independent hospitals. Single independent hospitals were chosen to reduce the effects on the study of being owned by a parent company that owned many other hospitals. In such cases, it might be difficult to separate the effects of IT in a single hospital and the effects of IT in the entire chain of hospitals. The hospitals in the sample were located all over the United States. No foreign hospitals were included in the sample. The goal of the sample of 1000 single hospitals was to have one-third of the hospitals with a high level of IT implementation, one-third of the hospitals with a moderate level of IT implementation, and one-third with a low level of IT implementation. The presence or absence of electronic medical records (EMR) and electronic medical administration record (eMAR) was used to give a rough estimate of where the hospitals are in their IT implementation development. These measures are probably not reliable enough or refined enough for analysis but give an idea of where hospitals are in their clinical IT development and allow for a rough division across the 1000 hospitals. With this procedure, approximately one-third of the hospitals had both EMR and eMAR, about one-third had either an EMR or an eMAR, and about one-third did not have either an EMR or an eMAR. This procedure helped to get a good representative group of hospitals from a low level of IT implementation to a high level of IT implementation. These data was in the HIMSSAnalytics database.

To create the questionnaire, an initial set of questions to measure the perceived accuracy of information and the factors of healthcare quality were created using the existing research literature in IT and healthcare. A pretest of the set of questions was completed by nurses and nursing professors who reviewed the questionnaire items for understandability and clarity. After the pretest, a pilot study was conducted. The pilot test consisted of having fifty-eight nurses and nursing managers fill out the questionnaire containing the questions. This group of nurses and nursing managers also was asked to make suggestions on improving the questionnaire items. Finally, principal component analysis (PMA) was run on the results from the pilot study to determine the validity of the questionnaire using .40 as a cutoff for items to be included in a factor. Cronbach’s alpha analysis was used to determine the reliability in the pilot sample using the standard cutoff of .70. The set of questions from the pilot study had good validity and reliability according to the results of these statistical techniques.

The final questionnaire for this study consisted of three items for the perceived accuracy of information and ten items total for the quality of healthcare, three items for assurance, three items for collaboration, and three items for safety. As mentioned, this questionnaire was mailed to CNOs in 1000 single hospitals. A letter accompanied the questionnaire requesting that the survey be completed. Each paper questionnaire was stamped with a unique identifier. The survey could be completed either by a Web-based questionnaire or the paper based questionnaire and returned in a pre-paid postage envelope that accompanied the mailed survey. The Web based questionnaire could be accessed through the unique identifier.

Two follow-up email contacts was also done, one about three weeks after the mailing of the questionnaire, and the next about two weeks after the first email. The study used the unique identifier to track each hospitals response. This unique identifier was used to check for duplicate questionnaires and to merge the primary data from the questionnaires with secondary data from HIMSS Analytics database. With the unique identifier, anonymity was maintained.

This study used the “key informant” methodology. Segars and Grovers [40] said about key informant, “Such informants are not chosen at random; rather, they are chosen because they possess special qualification such as status, experience, or specialized knowledge. CNOs were chosen for this study because of their experience and specialized knowledge about the accuracy of information and the quality of healthcare in their respective hospitals.
They were asked to provide information on these measures that refer to an aggregated organizational level of analysis.

The CNO is the highest ranking administrative registered nurse in the hospital. Most CNOs have spent a number of years at the clinical bedside. Many have advanced academic degrees and training in business practice, nursing administration and other related fields in healthcare. The position of CNO requires responsibility for many hospital departments as well as an extensive knowledge of the daily operations and routines in the hospital. Among other responsibilities, the CNO’s primary duty is the provision and assessment of the quality of healthcare in the clinical setting. A member of the executive team, it is the CNO who has perceptions of the quality of healthcare and the quality of information nurses use in the hospital setting [20].

Other information requested of the CNO included length of tenure at the hospital, years of experience, highest degree, gender, age range, job level, and name of position. These attributes of practice helped certify that this key informant was knowledgeable and capable of answering the questionnaire with accuracy.

The data collection for the factors in this study was part of a larger study. The questions used in this study are in Appendix 1 at the end of this study. There are three items for each of the variables, (perceived) Accuracy of Information, Assurance, Collaboration, and Safety.

Of the 1000 questionnaire sent to the CNOs, 214 usable responses were received for a 21.4% response rate. This response rate is comparable to other studies targeting high level executives in other organizations. Non-response analysis was needed to make sure that the hospitals of the responding informants did not differ significantly from the hospitals in the population that did not respond. Early respondents were compared with late respondents on the questionnaire items to make sure that there was no significant difference between the two groups [30]. No differences were found using a t-test.

Tests for convergent validity and discriminant validity were completed on the survey items. Convergent validity is the extent to which the indicators accurately measure what they are supposed to measure [21]. Discriminant validity assures that the factors of the questionnaire are truly independent of each other and not measuring the same concept. Hair et al. [21] suggest that validity can be analyzed using the average variance extracted (AVE). The AVE “reflects the overall amount of variance in the indicators accounted for by the latent constructs (the factor)” (p. 642). The higher the AVE, the more likely the items are truly representative of the underlying factor. Recommended value for AVE is typically 0.50 or higher [21]. The AVE was calculated and inspected for each factor to make sure that each of the values was above the cutoff of 0.50. The AVEs are as follow: Perceived Accuracy: .78; Assurance: .54; Collaboration: .78; Safety: .63. In all four cases, the values were well above this threshold.

Another test for validity uses the AVE. With the test, the AVE of the factors is compared to the cross-correlations for all cross-correlations of the factors. If the AVE is higher than the cross-correlations, it is another source of support for validity of the measures in this sample. The cross-correlations for the measures are as follow. Perceived accuracy: Assurance (.44), Collaboration: (.48), Safety (.47); Assurance: Collaboration: (.35), Safety (.50); Collaboration: Safety (.47) (all significant at .05 level). In all cases, again, the AVEs for the factors were above any of the cross-correlations among the factors. The correlation between any two factors should be less than 0.90, which denotes that the factors are independent of each other and, thus, have discriminant validity. In inspecting the correlations among the factors, all of the correlations were well below this cutoff of .90. These tests indicated that the measurement items had good convergent validity and discriminant validity.

The factors were also tested for reliability using Cronbach’s alpha. The most commonly used threshold for reliability measures is 0.70 for Cronbach’s alpha (Hair et al., 1994). The reliabilities for the measures are as follow: Perceived Accuracy: .84; Assurance: .70; Collaboration: .85; Safety: .71. All of the factors had measures above .70. These results provided evidence that the measures were reliable.

The level of IT implementation is measured in this study by the number of the IT applications (e.g., CDR, CDSS, CPOE, LIS) that the hospitals have that are live and operational. The data for these applications and their definitions are taken from the HIMSSAnalytics’ database [22]. The nine IT applications as defined in Table 1 were considered for each hospital. Therefore, the range for IT implementation measure could range from zero to nine.

5. Relationship analysis

The relationship model was analyzed using PLS. PLS allows for analysis within a smaller sample size than covariance-based structural equation models (SEMs), like AMOS and LISREL [13]. The intent of this study was to examine the relationships among the level of clinical IT implementation, the perceived
accuracy of information, and the quality of healthcare. The literature review reveals that the perceived accuracy of information was a likely mediator between the relationship between IT implementation and the quality of healthcare.

The results of the PLS analysis are shown in Figure 2. Hypothesis 1 is shown as the relationship between the level of IT implementation and the perceived accuracy of information. Hypothesis 1 is supported as the relationship between these two factors is significant and positive. The relationship was significant at less than the .05 level with a beta of .20. Hypothesis 2 is the relationship between the perceived accuracy of information and the quality of healthcare. The measures for the quality of healthcare are assurance, collaboration, and safety. As can be seen in Figure 2, this hypothesis is supported. The perceived accuracy of information measure is positively and significantly related to all three quality of healthcare measures thus providing evidence for support. All of the relationships were significant at less than the .05 level with beta weight of .24 for assurance, .32 for collaboration, and .28 for size.

![Figure 2: Results of the PLS Analysis](image)

6. Discussion

The value of IT in many other industries has been shown in past studies [32]. However, there have been very few large-scale quantitative studies to present evidence that IT will have a similar impact in the healthcare industry and, more specifically, in hospitals. This study is important because it is one of the first quantitative studies to investigate the value of IT in this industry. The first hypothesis purports the relationship between the level of IT implementation and the perceived information accuracy for clinical decision making in hospital care units. The level of IT implementation was measured using the number of clinical IT applications for hospitals as reported in the HIMSSAnalytics database [22]. The perceived information accuracy data was collected from the 214 responding CNOs from the sample of 1,000 hospitals that were contacted for the study. In each case, the level of IT implementation was positively and significantly related to the variables.

The level of IT implementation was positively related to the perceived accuracy of the information used for clinical decision making. Accuracy is an extremely important aspect of clinical
decision making. Every year, thousands of patients die because of errors in the medical data [9]. Anything that can help reduce this number should be welcomed into the industry. If IT does indeed increase the perceived accuracy of information for clinical decision making as indicated from the findings in this study, healthcare organizations need to consider the implementation of IT for this reason alone. Of course, opportunity costs (trade-offs) that something else might be better have to be weighed, but IT should certainly be considered in its relationship with accuracy, according to the results of this study.

Problems with perceived accuracy of information in hospitals can lead to many different negative outcomes, including dose error (e.g., overdose, under-dose, missed dose), frequency errors (e.g., too many or too few medical interventions), drug interactions, illegible orders, known allergy to drug not being disclosed, preparation error, and delays in treatment [7]. If clinical information given to healthcare providers is inaccurate, these and other similar problems are much more likely to occur. In this study, evidence indicates that the level of IT was directly related to the perceived accuracy of information for decision making. If the perceptions of the CNOs about the accuracy of information for decision making are correct, this suggests that IT may also contribute to reducing the number of these types of problems and making hospitals safer for patients.

As expected, all of the links between the factors for perceived accuracy of information and the factors for the quality of healthcare were positively and significantly related. The accuracy factor was related to assurance, tangibles, collaboration, and safety. Evidently, having perceived accurate information helps nurses deliver safer care with more confidence. According to the data, having perceived accurate information helps nurses perform healthcare services correctly the first time with little need to repeat this care. According to the CNOs, it makes the nursing staff more dependable in handling patient needs. A competent nursing staff that performs healthcare services correctly is a valuable asset to any hospital. Perceived accurate information also helps nurses deliver safer healthcare than when information contains errors. Although the finding is certainly intuitive, this may be the first study to empirically provide evidence of the relationship. Whether intuitive or not, this finding is certainly very important to healthcare practitioners. A major concern of patients in hospital settings is the safety of the healthcare that they are receiving. As mentioned earlier, the Institute of Medicine reported that many Americans suffered because of errors in the delivery of their medical care [25].

Perceived accurate information helps nurses communicate and collaborate with other departments and physicians. The evidence in the study indicates that the more accurate the information nurses receive, the more willing they are to collaborate and communicate about patient care with other caregivers such as pharmacists, laboratory personnel, and physicians. Other caregivers could also have more confidence in accepting information from nurses if the nurses have more accurate information. When physicians make their rounds in the hospitals, they must be able to depend on the status information they receive from nurses to make decisions about medical care. It would seem that the more accurate the information, the more physicians would trust and seek out information from nurses.

7. Limitations

Limitations to this study are acknowledged and addressed. First, this study utilized a questionnaire method of data collection. With this type of study, the researcher must try to ensure a large sample for adequate analysis. Though the survey response was 21% and not atypical of many studies, a larger sample size would have been preferred.

Another limitation is the use of CNO as key informant in this study. Although it is the CNO who is responsible for the quality of care, information received and used by the RN in the hospital, there are others that may have opinions that could affect the accuracy of information such as the chief information officer, physicians and unit managers for hospitals and the registered nurses in direct care of patients.

The use of secondary data is another limitation. Though the use of secondary data is time and cost efficient, the researcher has no control over how the data were collected or any biases that may have been incorporated into the data. There is also potential for data coding and data entry errors that the researcher is unaware of. The HIMSSAnalytics Database provides online information for more than 5,000 healthcare facilities in the U.S. The Website for HIMSSAnalytics Database offers assurance that there data collectors are expert at gathering data from hospitals and healthcare facilities.

8. Conclusion

This study has examined the value of clinical IT applications in single system hospitals in increasing the perceived accuracy of information and, ultimately, the quality of healthcare. Clinical IT applications are
relatively new in hospitals compared to IT in other industries. Preliminary studies like this one are valuable because they can provide evidence of the impact of IT in healthcare organizations like hospitals. It is encouraging that the results of this study points toward positive outcomes for the implementation of IT in healthcare organizations. There is pressure on healthcare organizations to reduce errors and provide a better quality of care. It seems from the results of this study that IT can play a significant role in helping to satisfy this need. There should, of course, be many more future studies of the effects of IT in healthcare organizations so more concrete recommendations can be made on improving the overall quality of healthcare.

References


Appendix 1

Measures Used in the Study Measured on 5-Point Likert Scale from Strongly Disagree to Strongly Agree

**Accuracy**
1. The information used for clinical decision making has numerous accuracy problems that make it difficult for nurses to care for patients.
2. The information used for clinical decision making that is provided to nurses is accurate.
3. The information that is used for clinical decision making is correct and adequate to provide excellent patient care.

**Assurance**
1. Our nursing service is one of the best at providing reliable healthcare.
2. Our nurses are known for performing services right the first time.
3. The nursing staff is dependable in handling patient needs.

**Collaboration**
1. The nurses in the hospital can collaborate with other departments such as pharmacy and laboratory.
2. Our nurses communicate with pharmacists and laboratory personnel.
3. The nursing staff communicates with physicians on the status of patients.

**Safety**
1. Our nursing staff has created a safe environment for patients.
2. Medical errors from nurses are rare compared to other hospitals of this size.
3. The nurses at this hospital are vigilant about preventing accidents among patients.