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The Impact of a Clinical Information System on Quality of Patient Care in a Large Public Healthcare Institution in South Florida

Donna Marie Lewis

THE IMPACT OF A CLINICAL INFORMATION SYSTEM ON QUALITY OF PATIENT CARE IN A LARGE PUBLIC HEALTHCARE INSTITUTION IN SOUTH FLORIDA

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

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in Leadership in Education in

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Barry University

by

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Barry University

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Area of Specialization: Educational Computing and Technology

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ABSTRACT

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IN SOUTH FLORIDA

Donna Marie Lewis

Barry University, 2008

Dissertation Chairperson, Dr. Joel S. Levine

Purpose

The purpose of this study was to determine the impact of a clinical information system on quality of patient care in a large public healthcare institution in South Florida. This dissertation involved one selected site, which was experiencing the dilemma of outdated information technology and had major concerns in the area of patient care. It was expected that this study would look at the situation as it existed, review previous studies, access feedback and provide recommendations relative to the health information infrastructure in this institution.

Method

This was a quantitative research study using a causal comparative methodology to determine the impact of a clinical information system on quality of patient care. The study examined two sets of data: a survey and publicly available statistics for lab and pharmacy. Site selection was based on the fact that this health care system was the only public safety-net hospital and was the largest teaching hospital in the state of Florida. Based on the number of admissions to a single healthcare institution, this hospital was one of the nation's busiest.

Major Findings

The results of this study were presented in relation to the three identified null hypotheses. Statistically significant differences were found when testing 2 out of the 3 null hypotheses between the old system and the new system. A statistically significant difference in quality of patient care did not exist in examining the number of pharmacy errors. In examining the number of lab errors, a statistically significant difference in quality of patient care existed. A statistically significant difference in user satisfaction existed.

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To my parents, Horace and Cordella, for their indispensable role in instilling values in me, my sister Gillian for encouraging words, my daughter Courtney-Micaela for her patience and finally, Aunt Joyce, for her support. I thank you all. I will always treasure my grandmother's favorite, Psalm 91: I will say of the Lord, he is my refuge and my fortress: my God, in him I will trust.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Background and Significance

The government's three biggest concerns in healthcare today are cost, quality of care and patient's inability to control their own treatments. Information technology (IT) professionals working together with healthcare professionals share a vision. The vision is to improve the quality of care and safety, reduce delivery costs and administration, simplification and efficiency. Medical professionals aim to avoid the many catastrophic consequences of not using information technology in healthcare (First, 2006). Healthcare institutions today are under enormous pressure to reduce the rate of errors by preventing adverse events, facilitating a more rapid response after an adverse event has occurred, and by tracking and providing feedback about adverse events.

Many health care executives believe that IT will bring some kind of competitive advantage and will contribute to organizational strategies. On the other hand it is difficult for most executives to identify a large number of prior IT investments that have yielded significant returns to financial and competitive performance. Yet it is very easy to find many examples of IT failures which went over budget. In a study reported by C.W. Bell only 49 percent of health care Chief Information Officers (CIOs) felt that IT improved the quality of care, and only 26 percent of Chief Operating Officers (COOs) believed that this was the case. Only 45 percent of health care executives felt that a positive return on investment on IT is "very likely" (Bell, 1999).

IT strategy is particularly important in healthcare institutions. There should be a clearly defined link between the organizational goals and the IT initiatives. Creating a strong IT infrastructure and improving the relationship between IT and the rest of the organization is crucial. Acquiring technologies such as internet based clinical

applications enable organizational transformation. The strategy of an organization has two major components: formulation and implementation. Formulation entails decision making relative to mission and goals. Formulation also involves awareness of competing ideas, then choosing the best option. Understanding the need for IT formulation is important since it sustains the IT mission to support improvement of the quality of care. Implementation involves decision-making relative to structure, skills acquisition, creating organizational competences, and change, in order to achieve goals (Henderson and Venkatraman, 1993).

The subject of medication errors is a major area of concern in healthcare today. The escalation of incidents involving medication errors over the past few years has focused attention on this troubling issue. As a result of this growing concern, legislation, healthcare commissions and organizations have reviewed the frequent occurrences of medication errors and are taking measures to prevent them. Successful implementation of information technology is important in the overall transformation of healthcare. Healthcare institutions today are under enormous pressure to reduce the rate of errors by preventing adverse events, facilitating a more rapid response after an adverse event has occurred, and by tracking and providing feedback about adverse events.

Statement of the Problem

This dissertation described a study of one selected site, which was experiencing the dilemma of outdated information technology and had major quality concerns in the area of patient care. It was expected that this study would provide recommendations relative to the establishment of a health information infrastructure in this institution. An essential element of this infrastructure was the development of an Electronic Medical Record (EMR), which could be integrated statewide, then eventually nationwide. It was

intended to create a design for new information technology including automated medication delivery systems that had enormous potential to improve quality of patient care. Safety, involving an appropriate medication process, was one of the major concerns at this healthcare institution.

The intent was to improve this process with hand held devices, a clinical information system with online real time checking, followed by monitoring to ultimately assist in decision-making. Included in this medication process was mandatory reporting where healthcare professionals were taught to be accountable for errors (Tokarski, 2004). Notably, Florida is leading the nation in publicly reporting health care information. Florida legislature passed a law in 2001 mandating that all healthcare professionals in Florida complete a 2 hour course on the topic of prevention of medical errors (FL Committee Substitute, 2001). The availability of more powerful computers, combined with wireless technology and telecommunications infrastructures put more power in the hands of caregivers and clinicians. The purpose of this study was to determine the impact of a clinical information system on quality of patient care at a large public healthcare institution in South Florida.

Major Issues, Research Questions and Hypotheses

Based on the literature, the following research question was examined:

Is there a difference in quality of patient care as a result of using a clinical information system as evidenced by the number of pharmacy errors, the number of lab errors and user satisfaction?

This research question suggested the following null hypotheses for this study:

Ho There will be no difference in quality of patient care based on the number of pharmacy errors.

H_{O2}: There will be no difference in quality of patient care based on the number of lab errors.

H_{O3}: There will be no difference in quality of patient care based on user satisfaction.

The alternate hypotheses were:

H_{A}□: There will be a difference in quality of patient care based on the number of pharmacy errors.

H_{A2}: There will be a difference in quality of patient care based on the number of lab errors.

H_{A3}: There will be a difference in quality of patient care based on user satisfaction.

In response to providers, policy makers and researchers, the Agency for Healthcare Research and Quality's (AHRQ) Quality Indicators (QIs) provide measures identify variations in quality of care. QIs are a set of measures used with hospital inpatient discharge data to provide a perspective on quality. Volume of errors provides another perspective on quality. *Volumes*, as there is evidence that a higher volume of pharmacy errors is associated with lower quality of patient care. In examining volumes the correlation between number of lab errors and patient care was also revealed. High quality levels were linked to lower error rates.

The three aspects of quality measured in this study included the number of pharmacy errors, the number of lab errors and user satisfaction. If a clinician or employee did not find the clinical information system useful, this could slow down productivity and ultimately impact patient care. Automated systems which facilitated

advanced level coding (e.g. web based drug interaction checking for pharmacy) could *impact* quality of patient care in with the aim of speeding up the correction process.

Healthcare organizations' vision is to use IT improve the quality of care and safety, reduce costs and simplify processes and improve overall efficiency. It is argued that computer systems deliver benefits in reducing medication errors. Although organizations are constantly evolving, the proper application of technology exists to turn vision of improved healthcare through advanced technology into reality. The healthcare industry needs to move beyond a fixation on numbers and get on with the job of improvement (Richardson, Berwick & Bisgard, 2000).

Medication errors may occur at three critical points: when ordered by a physician, dispensed by a pharmacist, or administered by a nurse. A number of prescribers continually use dangerous abbreviations and dose expressions. Despite repeated warnings by the Institute for Safe Medication Practices regarding the dangers of using these abbreviations, this practice continues (Joint Commission on Accreditation of Healthcare Organizations, 2001). Medication errors can also occur at the treatment or preventative care stages in the process of providing patient care (Committee on Quality of Health Care in America, 1999). Information systems help to eliminate the need for abbreviations since doses appear as preformatted text on the computer screen.

Families of patients should be encouraged to ask questions, especially if something seems wrong (Stewart, 2000). The issues examined address the challenge of many institutions experiencing change that started at the top level and moved throughout the institution.

Issues in accepting a technology that enhanced the medication process required the examination of the evolving relationship between healthcare professionals. As they

worked to implement the new clinical information system various efforts were in progress to change culture, even to the level where services and benefits were rendered and expectations were placed upon the patients. Educating healthcare professionals becomes crucial in the success of any technology implementation process.

The number of errors was an excellent indicator or quality of patient care. This study showed the correlation between a clinical information system implementation and errors. The relationship was studied based on the number of pharmacy and lab errors. The dependent variable in this study was quality of patient care (number of pharmacy and lab errors, and user satisfaction) within the healthcare institution. The independent variable was the clinical information system. Popular views on the use of technology stated that it should produce significant gains in the clinicians' efficiency and effectiveness in the medication process. Contrasting views stated that information technology was disruptive and expensive and had generated many negative effects on people who went from manual tasks to using computers or their products in the performance of their work, and sometimes seemed uncontrollable by these clinicians.

Basic Assumptions

It was assumed that the employees who completed the surveys and instruments answered the questions truthfully. It was assumed that incident reports on medication errors are completed correctly and questions on those reports are answered honestly. It was understood that any patient data used was primarily data obtained from reliable sources. It was assumed that the instrument developed by Bailey and Pearson (1983) was a reliable and valid way of measuring clinicians and other employees use of information systems.

Limitations

Since the organization used in this study was a large teaching healthcare institution, generalizability was a factor, in that the results of the study were not generalizable to clinicians in other institutions. At the time of this study, users were in a learning phase. Another limitation related to adaptation. Interestingly, it was argued that younger clinicians adapted to information technology faster than older clinicians. In studying the three aspects of quality by way of a clinical information system, it was important to understand and recognize as a limitation that errors occurred, which were not reported. It should also be noted that this study did not examine all the indicators of quality of patient care.

Definition of Terms

A Clinical Information System (CIS) is a comprehensive, integrated information system designed to manage the administrative, financial and clinical aspects of a hospital. This encompasses information and data processing. The aim of a CIS is to achieve the best possible support of patient care and administration by electronic data processing. Its software components have specialty specific extensions as well as a large variety of sub-systems in medical specialties (e.g. Radiology Information System and Laboratory Information System). CISs concentrate on patient- and clinical state- related data (EMR).

Information technology is the development, installation and implementation of computer systems and applications. Information technology can be further described as applied computer systems – both hardware and software, and often including networking and telecommunications, usually in the context of a business or other enterprise.

Information Technology Strategy is a crucial requirement for a competitive position in the marketplace today. Effectiveness means quickly delivering advanced

technologically complex solutions and responding rapidly to change. It should provide products and services for the complete IT solution beginning with strategy and feasibility studies, through implementation testing and support.

Quality of Patient Care in this study refers to: the number of pharmacy errors, the number of lab errors and a score on the user satisfaction survey. These errors are events that may cause patient harm while in the control of the health care institution.

A pharmacy error is any error recording by the Pharmacy Dispense Management (PDM) system's exception report as measured by frequencies in a one-month period. An admission by a clinician where a medication was incorrectly administered is not defined as an intentional act of wrongdoing.

A lab error is any error recording by the Lab Information system's exception report as measured by frequencies in a one-month period.

User satisfaction is a score on the Doll and Torkzadeh End-User Satisfaction Measures survey. This 12-item instrument measures the extent to which computer applications meet the end-user's needs with regards to five factors, namely (a) content, (b) accuracy, (c) format, (d) ease of use, and (e) timeliness.

Setting

The study targeted a large public healthcare institution in South Florida which employed 4,104 physicians and over 5,927 clinicians and other employees. Because the institution had been in operation for over 100 years and some clinicians were employed there for over 30 years, the age range was extremely wide. In 1973, a Quality Improvement and Joint Conference Committee was formed at this institution. The committee, pursuant with Florida law, took responsibility for reviews and made recommendations to the Hospital Board regarding quality assessment and improvement

of facilities activities within the institution. The reports generated focused on implementation through quality assessment and improvement and risk management programs. This included the various instruments used by medical, administrative and other staff for monitoring and evaluating the quality of patient care. The aim was to identify and resolve problems as well as identify opportunities to improve care.

Chapter 2: LITERATURE REVIEW

Introduction

In conducting a review of the relevant literature, several themes emerged which examined journals, online databases and text books applicable to both information technology and healthcare. Preliminary broad-spectrum topics included a review of the history of Information Technology and systems, the impact of technology on healthcare (to include information systems in healthcare and technology in medicine). Subsequent topics included data systems, Electronic Medical Records (EMRs), quality of care in the United States of America. Healthcare informatics, the use of computers to solve clinical or healthcare problems, is new, immensely challenging and rapidly evolving.

History of Information Technology and Systems

The History of Information Technology and Systems is divided into four basic periods. Each period is distinguished by basic knowledge used to solve the input, processing, output and communication problems of the time. The first period was known as the premechanical age (3000 B.C.-1450 A.D.), where writing and alphabets, books and the first numbering system were introduced. The second period was known as the mechanical age (1450-1840), when the first information explosion took place with the advent of such machinery as the slide rule. The third period, the electromechanical age (1840-1940), saw the discovery of ways to harness electricity in such a way that knowledge and information could be transformed into electrical impulses. The fourth period, the electronic age (1940-present), saw the first high-speed general purpose computer using vacuum tubes. The tubes were replaced by transistors, which were eventually replaced by integrated circuits (micro chips) (Laudon, Traver & Laudon, 1996).

In the 1970s mainframe computers were used to centralize computers and data. The main focus was to automate existing processes such as payroll, billing and inventory. In the 1980s, personal computers (PCs) and local area networks (LANs) were installed which allowed individual departments to set up their own computer systems. End-user computing with word processors and spreadsheets made the departments less dependent upon the IT department. In the 1990s Wide Area Networks (WANs) became the corporate standard with the main focus on corporate learning and central control. Senior management was more interested in system and data integration. In the 2000s, WANs expanded via the internet to include global enterprises. The focus was on efficiency, speed and data sharing across systems.

Information Technology in Healthcare

Healthcare in historical terms, especially related to procedures has always been challenging. The stage was already set from as far back in times when operations and surgeries were performed by candlelight, amputation was the only answer for many diabetics, and data was stored mainly in the memory. At the start of the 21st century with advances in methodology, healthcare had to become more multifaceted and therefore, more challenging.

With world population growth and movement, there have been more widespread diseases including new ones, such as Severe Acute Respiratory Syndrome (SARS) and Human Immunodeficiency Virus (HIV/AIDS). An important factor in the curtailing and control of some of these new diseases is early detection and diagnosis by recording, analyzing symptoms and disseminating related observations. Fortunately, information technology has itself not remained static but has kept pace with, and even surpassed, the dynamics of social and communicative development in what has become a world global

village. In the United States of America (USA) and other leading countries, IT has become a metaphor for development, but the impact of its vast potential in the healthcare sector is still lagging.

It may be surprising to realize the relatively small amount of research available on the effectiveness of IT on healthcare; e.g. Quality of patient care in institutions, government or otherwise. Such research is a fairly new arena, which would demand a more in-depth approach by healthcare providers. The faithful bedside paper chart is being replaced by accumulative database or EMRs containing the patient's age, medical history, tolerance levels, genetic conditioning, e.g. blood-work and allergies, even religious and cultural conditioning. The impact of technology on healthcare and medicine will depend largely on the growing importance of information systems alongside its counterpart, quality inpatient measurement indicators.

Relatively little research on the effectiveness of information technology is available. In order to achieve major gains in improving quality of patient care and safety in the mediation process, it is important to determine if IT can play a key role in the transformation of healthcare.

Safety in the Medication Use Process

In the U.S., studies used by the Institute of Medicine show that the rates of injury and death can be reduced by improvements in care (Brennan, 2000). The main message from the Institute of Medicine report is that most errors were the result of faulty information systems storage and retrieval, rather than faulty people (Kohn, Corrigan & Donaldson 2000).

Over the past few years, studies determining the risk of harm caused by medical care have increased (Bates & Gawande, 2003). Reducing errors and improving safety

costs money in the short term. About 100 patients per day will die in hospitals because of injuries from their care. A health reporter for a leading newspaper died following an overdose of a chemotherapeutic agent (Zyla, 2000). A patient in a well known Florida hospital had the wrong foot amputated (Willis, 2001). Loss of life will continue until new ideas are translated into actions that could actually prevent the added burden of medical injury from errors (Berwick, 2003). Very little data exists on errors that occur in physicians' offices, nursing homes, pharmacies, urgent care centers and home health delivery (AHRQ, 2000). Managing of medical data through technology support systems has potential in reducing medical errors.

Electronic Medical Records

Electronic Medical Records (EMRs) can be categorized in seven main topics. These capabilities are viewing, documenting, ordering, messaging, care management, analysis and reporting, and patient-directed (e.g. online prescription ordering). Some EMRs include integrated billing and scheduling capabilities. Viewing- the electronic viewing capability is a core feature. Clinicians can view past progress notes, problem lists (chief complaints), past medications, and allergies. They can also view lab results, consultant reports, hospital inpatient data and other related clinical data.

Documenting – The electronic documenting capability enables users to record progress notes, chief complaints and diagnoses, allergies, prescription and other data electronically. Clinicians can enter data in the examination room or patient room. Electronic forms or templates are specific to the type of visit or to the patient's disease or condition (e.g. High blood pressure or neck pain). Features of electronic forms can vary. Even users of the EMR can vary in their use of electronic forms and their features. These

electronic forms can actually prompt physicians to guide the clinicians' exam and discussion with patients.

Ordering- Electronic ordering allows users to enter prescriptions into electronic forms, allowing them to select from different ordering possibilities, and to receive decision support (alerts) or drug/drug and drug/allergy interactions. Clinicians have the added ability to fax prescriptions to any pharmacy. This can be accomplished with the click of a button as opposed to using a separate fax machine to dial. Electronic prescribing is very popular today, especially since it has writing features, which makes the script legible.

Messaging – Electronic messaging capability allows clinicians to communicate effectively especially when it becomes necessary to send quick notes regarding contacting patients' family/patient's condition. These types of notes however, are not stored and are not legal part of the EMR.

Care Management/Follow-up - EMR disease management and prevention capabilities are somewhat similar to the documentation capabilities. Case Managers have to often pull health maintenance data for follow up referrals and care. Clinicians can customize templates with reminders and clinical practice guidelines.

Analysis and Reporting – Assists with searching identifying high-risk patients e.g. female patients mammogram, breast cancer and chemotherapy. Identify high cost procedures top ten diagnoses and procedures.

Patient-directed - EMRs have the capability to access a web site and communicate with providers or view their personal health record.

Billing and Scheduling – EMRs can be used in conjunction with integrated billing and scheduling systems. Interfaces allow seamless exchange of data between systems.

Enhanced integration lessens duplicate data entry and permits automated service capture and advanced visit level coding (Electronic Medical Records: Lessons Learned from Small Physician Practices, 2003).

Medical Informatics

Hospital information systems consisted of not only clinical and healthcare information, but also included telemedicine, computer-assisted instructions to patients and physicians and covered computer-assisted imaging and surgery. We have now become one with the computer screen.

Medical Informatics (MI) is the gathering of data from patients, processing and storing it, then transforming that data into information. It encompasses the entire domain of medicine and healthcare through information science and technology. Many hospitals implement computerized systems to ensure proper utilization of limited resources toward cost effective quality healthcare.

Telemedicine and computer assisted surgery have become an important part of medical practice. Image guidance technique is evolving and allows a new level of efficiency in surgical procedures (Bansal, 2003).

Quality Indicators

Quality Indicators, (QIs) as defined by the Agency for Healthcare Research and Quality (AHRQ), are measures of health care quality that make use of readily available hospital inpatient administrative data. QIs consist of 4 modules which measured different aspects of quality: Prevention QIs identify hospital admissions that evidence suggested could have been avoided, at least in part, through high-quality outpatient care. Inpatient QIs reflect quality of care inside hospitals including inpatient mortality for medical conditions and surgical procedures. Patient Safety Indicators also reflected quality of

care inside hospitals, but focused on potentially avoidable complications and iatrogenic events. Pediatric QIs both reflected quality of care inside hospitals and identify potentially avoidable hospitalizations among children

Summary

There are many other factors affecting the quality of patient care. This study focused on three main factors; pharmacy errors, lab errors and user satisfaction. At the selected public healthcare institution, these were major areas of concern in the decision to implement a new clinical information system. Designing, implementing and updating a clinical information system is a complex process. The process involves both a formal vision and strategic plan driven from the top level of administration. The process can be informal with fragmented changes occurring throughout the healthcare system. Changes in healthcare organizations' cultures are relevant as workers' perceptions and assumptions about their roles in healthcare delivery reform are being revised (Hercik, 1998).

It was anticipated that this study could contribute to the ongoing debate by helping to identify potential quality of care problems and share successes and focus on the need for further research in this fairly new arena. The intent was to share observations on the impact of technology on quality of patient care, review existing literature regarding conceptualization and implementation and post suggestions on ways to improve quality of patient care. From start to finish what we have done right becomes clear and we can then learn from our mistakes. To accomplish goals, there must be prudence in making use of current systems so that the focus will be on expanding global networks.

Improvement requires ideas, because new results cannot come from old methods. All improvement is change (Berwick, 2003). Improvement in healthcare delivery requires will, ideas, and execution (Nolan, 2000). Research continues as many authors put these models/ideas into practice. As the technology matures, its appeal will grow.

CHAPTER 3: METHODOLOGY

Introduction

This research focused on three factors which affected quality of patient care. The information systems produced many pharmacy and lab errors daily. These were tallied and the results analyzed. This research question suggested the following hypotheses for this study:

1. There will be no difference in quality of patient care based on the number of pharmacy errors.
2. There will be no difference in quality of patient care based on the number of lab errors.
3. There will be no difference in quality of patient care based on user satisfaction.

Design

This was a quantitative research study using a causal comparative methodology to determine the impact of a clinical information system on quality of patient care. The study examined two sets of data: a survey and publicly available statistics for lab and pharmacy. This method was chosen because the data was collected subsequent to the implementation, and the independent variable was not manipulated. Site selection was based on the fact that this healthcare institution was the only public safety-net hospital and the largest teaching hospital in the state of Florida. Based on the recorded number of admissions to a single healthcare institution, this hospital proved to be one of the nation's busiest.

Sample and Participants

The study examined two sets of data: a survey and publicly available statistics for lab and pharmacy. The first set of data was obtained through a survey. The participants in this survey were hospital employees at this public healthcare institution in South Florida. A voluntary sample of these employees was used. The major groups being studied originated from various units of hospital employees. They included physicians, pharmacists, lab technicians, and nurses, health information management staff, among others. All clinicians used information technology in their daily duties and for this study, were considered end users.

Data Collection Procedures

The survey was placed at random sites across the facility. The participants were advised that participation in this study was voluntary and anonymous and that results would be available in the department's central mailbox. No personal identity information was collected during the Likert – type survey of 12 questions. Surveys were placed in boxes by the researcher at different locations/departments throughout the institution, which included nursing stations, health information management departments, pharmacies, etc. These hard copy surveys in sealed envelopes, placed in boxes, were collected at the central locations. The responses were only looked at by the researcher, manipulated for analysis and kept locked in a secure place during the study, and will be kept up to 5 years after the study. Approximately twenty (20) locations/departments were chosen, each with 5-20 persons. Further information was gathered from lab and pharmacy statistics in addition to the survey. The purpose of this approach was to identify factors relevant to quality of patient care, collect meaningful data and perform detailed analysis of key indicators.

The second set of data consisted of lab and pharmacy statistics errors. The researcher obtained these summary reports by requesting them through the lab and pharmacy departments. Lab and pharmacy information systems tables (summaries) supplemented data collection activities. These data summaries were publicly available. Pharmacy was chosen because the pharmacy staff actually entered all orders, including medication orders, into the system, which housed a repository of clinical data to support clinical decision-making processes.

By providing assistance to clinicians in selecting the right medicine, they were able to determine interactions through the use of a drug information database. The database provided drug information, disease pathways, expert dosing support, and patient education materials. The system also alerted healthcare professionals of medication use problems. Non-desirable drug interactions and contra-indications were also incorporated into the system. By enhancing the awareness of look-alike and sound-alike medications, warning signs will help differentiate medications from one another (Cohen, 1999). Technology should assist especially when confusion exists between or among strengths, or similar sounding names (Florida Hospital Association, 2001). Bar-coded items scanned into the system should also reduce confusion between similar looking labels (Breland, 2000).

Instrumentation

The clinical information system was the independent variable. This was measured by an instrument developed by Bailey and Pearson (1983), Ives et al. (1983) produced a shorter form by excluding 26 items from the original 39-item instrument developed by Doll and Torkzadeh (1988, 1991, 1994). Raymond (1985) also adapted the instrument and developed a 20-item survey. The scale is a measure of overall user

satisfaction that includes a measure of the satisfaction of the extent to which computer applications meet the end-user's needs with regards to five factors, namely (a) content, (b) accuracy, (c) format, (d) ease of use, and (e) timeliness. The use of these five factors with the 12-item instrument developed by Doll and Torkzadeh (1988, 1991, 1994) served as a general measure of user computing satisfaction.

Table 1. Doll and Torkzadeh's End-User Computing Satisfaction Measures

Content
C1. Does the system provide the precise information you need? [F]
C2. Does the information content meet your needs? [F]
C3. Does the system provide reports that seem to be just about exactly what you need? [F]
C4. Does the system provide sufficient information? [C]
Accuracy
A1. Is the system accurate? [C]
A2. Are you satisfied with the accuracy of the system? [J]
Format
F1. Do you think the output is presented in a useful format? [C]
F2. Is the information clear? [C]
Ease of Use
E1. Is the system user friendly? [C]
E2. Is the system easy to use? [C]
Timeliness
T1. Do you get the information you need in time? [F]
T2. Does the system provide up-to-date information? [C]

The users were asked to answer the 12 questions with a 2 point Likert type scale. These global measures will be used to evaluate overall satisfaction.

Reliability

The reliability of measurement indicated the stability and consistency with which the instrument measured the concept. In this study, the internal consistency reliability of the scales was measured and the factors extracted from the exploratory factor analysis were subjected to reliability checks for further simplification. From the results of these analyses, the research model was then modified accordingly.

Validity

Construct validity testifies as to how well the results obtained from the use of the measure fit the theories around which the test was designed. The construct validity is usually verified through factor analytic techniques examining the items representing a particular construct that have high factor loadings on one construct and low loadings on all other constructs. All the items representing one or more of the research constructs belonging to each domain were subjected to factor analysis.

Data Analysis

The data collected was analyzed using SPSS 15.0 for Windows. A Z-test for proportions was used to compare proportions from two independent groups of errors for pharmacy. A Z-test was used to compare proportions from two independent groups of errors for lab. Each was measured by one or more manifest (observed or empirical) variables. A t-test was used to compare the means of the old mainframe system and the new clinical information system for user satisfaction.

The statistical or null hypothesis was:

Ho □: There will be no difference in quality of patient care based on the number of pharmacy errors.

H_{O2}: There will be no difference in quality of patient care based on the number of lab errors.

H_{O3}: There will be no difference in quality of patient care based on user satisfaction.

H_{A}□: There will be a difference in quality of patient care based on the number of pharmacy errors.

H_{A2}: There will be a difference in quality of patient care based on the number of lab errors.

H_{A3}: There will be a difference in quality of patient care based on user satisfaction.

For H_{01} and H_{02}, Z tests were used to compare proportions from two independent groups of errors. Data was also collected and reports were generated from the old lab and pharmacy systems. For the survey (H_{03}) a t-test was used to measure the use of information technology before and after implementation. A 'Likert' type scale was used in the user satisfaction survey. A random sample of 30 days prior to implementation compared to a random sample of 30 days post implementation should determine whether there was reduction or increase in errors and ultimately the impact on quality of patient care.

Summary

To determine if there were statistically significant differences in quality of patient care, two Z tests and one t-test was used. A Z-test was used to compare proportions from two independent groups of errors for pharmacy. A Z-test was used to compare proportions from two independent groups of errors for lab. A t-test was used to compare the means of user satisfaction. An alpha level of .05 was used to determine significance.

CHAPTER 4: RESULTS

Introduction

The findings and results of the study are described in this chapter. The first section reports the findings. The remainder of the chapter is a discussion of the data from the findings relative to the research question and each of the three null hypotheses. The research question asked: Is there a difference in quality of patient care as a result of using a clinical information system, as evidenced by the number of pharmacy errors, the number of lab errors and user satisfaction?

Findings

System Implementation and Acceptance

The old mainframe system was developed in-house in the 1990s. The need for a new system became evident with renewed concerns for implementing systems that would enhance efficiency, quality of care, and patient safety. The old mainframe system was replaced with a new clinical information system, with the goal of facilitating the delivery of health care and patient safety, and standardizing documentation of care in a single "enterprise" system accessible across the entire institution, and interfaced with critical niche systems. Comments made by the employees demonstrated early resistance (EHR Case Study, 2004). See Appendix A.

With the idea of change came anxiety and apprehension. Adaptations were made primarily according to the original project plan with the assurance that some target dates would be significantly delayed. Such delays are relatively common and quite natural. How would employees perceive and respond to the implementation process? Initially, there was resistance; this was followed by slow acceptance. Other observations included the fact that employees needed to be trained closer to the "go-live" date. Employees had

a tendency to forget what was taught to them if training took place too early in the implementation process (EHR Case Study, 2004).

Despite the efforts the staff went through while transitioning from paper to electronic, they had several barriers to manage. These barriers included fostering buy-in from clinicians, interoperability and cost, vendor management and training. Employees were encouraged to give feedback at several points during the implementation process. Participants in the process facilitated analysis of the results that led to the discovery of ideas and issues, which became the foundation for this large healthcare facility's positive development (EHR Case Study, 2004).

Successful implementation is characterized by mutual adaptation, after careful interpretation of the participants' responses. Although processes such as this one have been slow, project goals and objectives could be modified to suit the changing needs of employees, who tend to move from early resistance to slow, but eventual acceptance (EHR Case Study, 2004). For a highly technologic system such as this one, the system itself had to be significantly modified. Fortunately for this large healthcare institution, the new system was highly customizable.

Results

The results of this study are presented in relation to the three identified null hypotheses. The statistical program SPSS 15.0 for Windows was used to perform analysis of the data. A Z-test for proportions was used to compare proportions from two independent groups of errors for pharmacy. A Z-test was used to compare proportions from two independent groups of errors for lab. A t-test was used to compare the means of user satisfaction. An alpha level of .05 was used to determine significance.

Null Hypothesis 1

There is no difference in quality of patient care based on the number of pharmacy errors.

Pharmacy data was collected from both the old system and the new clinical information system then analyzed. A random sample of 30 days prior to system implementation compared to a random sample of 30 days post implementation was used. Pre implementation data indicated that there were 821 errors out of a total of 1,277 pharmacy orders. Post implementation data indicated that there were 745 errors out of a total of 1,398 pharmacy orders. A Z-test for proportions indicated a z score of 5.79 with $p > .05$. A statistically significant difference in quality of patient care did not exist in examining the number of pharmacy errors prior to and post implementation. Thus, the researcher failed to reject the first null hypothesis. The data is summarized in Table 1.

Table 1

	# of Errors OLD	#of Errors NEW	z score	p value
Pharmacy	821	745	5.79	0.585

Null Hypothesis 2

There is no difference in quality of patient care based on the number of lab errors.

Lab data was requested and collected and summary reports generated by both the old lab information system and the new clinical information system. Summarized data tables were collected and analyzed. A random of 30 days prior to implementation compared to a random sample of 30 days post implementation was used. Pre-implementation data indicated that there were 663 errors out of a total of 127,410 lab orders. Post implementation data indicated that there were 531 errors out of a total of 135,147 lab orders. A Z-test for proportions indicated a z score of 0.0042 with a $p < .05$.

In examining the number of lab errors prior to and post implementation, a statistically significant difference in quality of patient care existed. Thus, the researcher rejected the second null hypothesis. The data is summarized in Table 2.

Table 2

	# of Errors OLD	# of Errors NEW	z score	p value
Lab	663	531	0.0042	0.004

Null Hypothesis 3

There is no difference in quality of patient care based on user satisfaction. A total of 144 employees from 12 different departments completed the user satisfaction survey. The departments that participated in the study were Ambulatory, Childrens, Dialysis, Emergency, Health Information Management (HIM), Medical/Surgical, Mental Health, Nursing IT, PeriOperative, Pharmacy, Rehab and Womens. The data is summarized in Table 3.

Table 3

Participants By Department

DEPARTMENT	N	%
Ambulatory	12	8%
Childrens	14	10%
Dialysis	10	7%
Emergency	6	4%
HIM	18	13%
MedSurg	17	12%
MentalHealth	16	11%
NursingIT	12	8%
PeriOp	3	2%
Pharmacy	17	12%
Rehab	5	3%
Womens	14	10%
	144	100%

At the time of this study, the new system did not include a Surgical module. This component is scheduled for implementation in the near future. The low response rate of (2%) for PeriOperative is attributed to low usage. PeriOperative used neither of the two systems in the Operating Rooms. They used an entirely different system for surgery and typically used the systems in this study to view records or as a backup for verification purposes. Of the 144 respondents, 18 (13%) were from HIM, the highest number of participants from one department.

Based on the survey, the responses were grouped by system, old and new. The scores for each participant ranged from 0-12. A number 1 was assigned to each 'yes' response. A side by side comparison of both the old and new systems yielded the following results: For the old system, the highest number of responses originated from the user satisfaction questions surrounding Content. The lowest number of responses came from the Ease of Use question for the new system. In examining the categories for overall user satisfaction, – old system vs. new system - Ease of Use responses were the lowest. Out of 289 responses for this question, 95 reported that the new system was not easy to use. The high number negative responses to the ease of use question came from the Ambulatory department. The data is summarized in Table 4.

Table 4

User Satisfaction: 'Yes' Responses

	OLD	NEW
Accuracy	192	156
Content	359	282
Ease of Use	194	95
Format	190	141
Timeliness	174	168

Surveys were divided into two groups: Group 1 was the old system and group 2 was the new system. An independent t-test was used to compare means. In SPSS 15.0 for Windows, the variable for user satisfaction was labeled 'New' and 'Old'. A number 1 was assigned to the group for the old system and a number 2 was assigned to the group for the new system. Scores were entered into the appropriate cells using the variable names. The t-test used the grouping variables defined by a 1 or 2 and tested the variable 'User Satisfaction'. Group statistic results for User Satisfaction yielded the following: standard deviation = 4.5 for the old system and 3.9 for the new system. The data is summarized in Table 5.

Table 5

Group Statistics

	N	M	SD
OLD	144	7.7014	4.51118
NEW	144	5.8472	3.93713

The t-test for User Satisfaction indicated that t = 3.716, df = 286, mean difference = 1.854 and p = 0.031. The data is summarized in Table 6.

Table 6

t-test for means

t	Df	Mean Difference	p Value
3.716	286	1.854	0.031

A statistically significant difference in user satisfaction existed between the old system and the new system. Thus, the researcher rejected the third null hypothesis.

Summary

Statistically significant differences were found when testing two out of the three null hypotheses. Therefore, the researcher failed to reject only the first null hypothesis. Null hypotheses 2 and 3 were rejected. Chapter 5 will further discuss these results and conclude with recommendations for future research.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary of the Study

Purpose

The purpose of this study was to determine the impact of a clinical information system on quality of patient care in a public healthcare institution in South Florida. The study examined two sets of data: a survey and publicly available statistics for lab and pharmacy. The sample for this study consisted of lab data, pharmacy data and 144 employees who took part in the survey.

Significance

Successful implementation of information technology is important in the overall transformation of healthcare. Healthcare institutions today are under enormous pressure to reduce the rate of errors by preventing adverse events, facilitating a more rapid response after an adverse event has occurred, and by tracking and providing feedback about adverse events.

Method

The study examined two sets of data: a survey and publicly available statistics for lab and pharmacy. The first set of data was obtained through a survey. The participants in this survey were hospital employees at a public healthcare institution in South Florida. A voluntary sample of these employees was used. The survey was placed at random sites across the facility. The participants were advised that participation in this study would be voluntary and anonymous and that results would be available in the department's central mailbox. No personal identity information was collected during the Likert – type survey of 12 questions. Surveys were placed in boxes by the researcher at different locations/departments throughout the institution, which included nursing stations, health

information management departments, pharmacies, etc. These hard copy surveys in sealed envelopes, placed in boxes, were collected at the central locations. The responses were only looked at by the researcher, manipulated for analysis and kept locked in a secure place during the study and will be kept up to 5 years after the study.

Limitations

Since the institution used in this study is a large teaching hospital, generalizability is a factor, in that the results of the study may not be generalizable to clinicians in other institutions. At the time of this study, users were in a learning phase. Another limitation relates to adaptation. Interestingly, it is argued that younger clinicians adapt to information technology faster than older clinicians. In studying the three aspects of quality by way of a clinical information system, it is important to understand and recognize as a limitation that errors occur which are not reported. It should also be noted that this study does not examine all the indicators of quality of patient care.

Summary of Research Findings

The purpose of this study was to determine the impact of a clinical information system on quality of patient care in a large public healthcare institution in South Florida. The study examined two sets of data: a survey, and publicly available statistics for lab and pharmacy. The dependent variable in this study was quality of patient care (number of pharmacy and lab errors, and user satisfaction) within the hospital. The independent variable was the clinical information system.

The research question for this study asked: Is there a difference in of quality of patient care as a result of using a clinical information system as evidenced by the number of pharmacy errors, the number of lab errors and user satisfaction? The research question generated 3 null hypotheses for this study.

1. For Null Hypothesis 1 (H_{01}), a Z-test for proportions was used to compare proportions from two independent groups of errors for pharmacy.
2. For Null Hypothesis 2 (H_{02}), a Z-test was used to compare proportions from two independent groups of errors for lab. Data was collected and reports generated from the old lab and pharmacy systems.
3. For the survey, Null Hypothesis 3 (H_{03}), a t-test was used to measure user satisfaction and the use of information technology. A 'Likert' type scale was used in the user satisfaction survey. A random sample of 30 days prior to implementation compared to a random sample 30 days post implementation determined user satisfaction and its ultimate impact on quality of patient care.

Null Hypothesis 1

No significant results were found in the number of pharmacy errors over a 30 day period prior compared to a period 30 days post implementation. The test statistic yielded the value $z = 5.79$. With a z value > 1.645 for significance, the results coincided with the calculation for two proportions from two independent groups and determined that they were not significantly different from one another.

Null Hypothesis 2

Significant results were found in the number of lab errors over a 30 day period prior compared to a period 30 days post implementation. With a z value of 0.004 and a 95% confidence interval estimate, there was a difference in the proportion of lab errors between the old system and the new system.

Null Hypothesis 3

Significant results were found for user satisfaction. The difference in means for user satisfaction scores were 4.5 for the old system and 3.9 for the new system. For this

test, the revised End User Computer Satisfaction instrument developed by Doll & Torkzadeh (1988) was used to compare different information systems that performed similar functions. In addition to overall user satisfaction assessment, it could also be used to measure and compare end user satisfaction with different components of end user computing tasks (Xiao & Dasgupta, 2002).

Conclusions

Based on these results, the following conclusions were reached:

1. A significant difference was not found in a Z-test of pharmacy errors for a 30 day period pre implementation using the old system, compared to a period 30 days post implementation using the new system.
2. There was a significant difference in a Z-test of lab errors for a 30 day period pre implementation using the old system, compared to a period 30 days post implementation using the new system.
3. A significant difference was found in a t-test of user satisfaction between the new system and the old system.

With any new system, there is a learning curve. Users were comfortable with the old system and responded accordingly. It can be concluded that there was no significant difference in quality of patient care when information technology was implemented for pharmacy. This may be attributed to the fact that both pharmacy systems, old and new, had dose range and allergy checking, real-time drug interaction and warnings built in. There was a significant difference in quality of patient care after new technology was implemented for lab. There was a significant difference in quality of patient care based on user satisfaction. The results from this analysis provide representations for both direct and indirect impacts. The impact of Information Technology varies from one user to the

next depending on the user's computer skill level, the type of error, and the consequences of each error. Information Technology perceptions dimensions, and attitudinal perception both directly and indirectly vary through usage, satisfaction and performance as variables (EHR Case Study Report, 2004).

In this new era of collaborative organizations, information technology offers substantial promise for reducing the number of errors and improving productivity. Information technology already plays an important part in quality of patient care through assisted collaborative work. Users find ways of improving how they work together as they fulfill their information needs. With the introduction of Wireless on Wheels (WOWs), Personal Digital Assistants (PDAs) and Windows Terminal Server (WTS), users may become dysfunctional if they focus on technical issues, especially where they lack special expertise (EHR Case Study Report, 2004).

The fundamental difficulty in modern medical care is execution. Providing reliable, efficient care requires a degree of mastery of data and coordination that will only be achieved with the increased use of information technology (Bates & Gawande, 2003). Information technology can significantly improve overall patient safety by structuring actions, catching errors, and bringing decision support to the point of care.

Recommendations

1. For future research, a study should be conducted which attempts to measure additional components of satisfaction or additional indicators of quality of patient care.
2. At the time of this study, users were still in a learning phase. Based on differences in frequency of use, attitudes and varying capabilities, some users were not yet familiar with the new system; therefore this study should be

repeated within the next 8-12 months. The time it will take employees to become more familiar with the system, and feel comfortable using the system for daily workflow processes will vary. Training is essential to ensure that the system will be utilized to its full error-reducing potential.

3. Although the sample was appropriate for this study, research should be conducted based on position groups e.g. physicians, nurses, pharmacists etc.
4. This study should be expanded to include other large healthcare institutions so that the results could be more generalizable.
5. As it is argued that younger clinicians adapt to information technology faster than older clinicians, this study should be conducted to compare clinicians by age.
6. This study should be repeated using the organizational measures such as large vs. small, private vs. public, more specialized vs. less specialized, urban vs. rural healthcare organization.

Improvement in healthcare delivery requires will, ideas, and execution (Nolan, 2000). Various research networks are evaluating ways of using information technology to improve overall quality of patient care. In order to improve, the healthcare industry must transform while considering the implications for medical care, research and policies. As the technology matures, its appeal will grow.

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Appendix A

We are dealing with staff with a range of computer skills. Getting everyone trained will be a challenge, even in terms of getting staff up to speed on how to use Windows

Before, not everyone was using the old system. Now everyone will have to use the new system, including staff at different levels of education and computer skills

They emphasized how much they could interact with the system, but I would rather interact with the patient

Voice of the Clinicians – paraphrased comments from focus group of nurses and physicians. (EHR Case Study, 2004).

Appendix B

Barry University
Cover Letter

Dear Research Participant:

Your participation in a research project is requested. The title of the study is "The Impact of a Clinical Information System On Quality of Patient Care in a Large Public Healthcare Institution in South Florida". The research is being conducted by Donna Lewis, a student in the Educational Technology department at Barry University, and is seeking information that will be useful in the field of Educational Technology. The aims of the research are to share observations on technology's impact and find ways to improve quality of patient care. In accordance with these aims, the following procedures will be used: surveys will be conducted at random sites across the facility, supplemented by pharmacy and lab data**.** We anticipate the number of participants to be 100.

If you decide to participate in this research, you will be asked to complete a 2 minute survey. Should you decline to complete the survey, there will be no adverse effects on your employment.

There are no known risks to you. The benefit to you for participating in this study is that your contribution to the body of research on technology in healthcare may facilitate decisions in the near future.

As a research participant, information you provide will be kept anonymous, that is, no names or other identifiers will be collected on any of the instruments used. Data will be kept in a locked file in the researcher's office. By completing and returning this survey you have shown your agreement to participate in the study.

If you have any questions or concerns regarding the study or your participation in the study, you may contact me, Donna Lewis, at (305) 343-7217, my supervisor, Dr. Joel Levine, at (305) 899-3608, or the Institutional Review Board point of contact, Mrs. Nildy Polanco, at (305) 899-3020.

Thank you for your participation.

Sincerely,

_____

Donna Lewis

Appendix C