AN ABSTRACT OF THE DISSERTATION OF

John W. Holliday for the degree of Doctor of Philosophy in Industrial Engineering presented on May 17, 2010

Title: The Effects of CI Tools and Implementation Practices on Hospital Performance.

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Toni L. Doolen

Continuous Improvement (CI) is an integral part of hospital administration. This study examined the relationship between five CI variables against six hospital criterion measures of, wait times to prepare a room, patient costs per day, waiting time for lab results, reportable errors, patient satisfaction, and employee satisfaction. The research was conducted using information gathered from 17 returned surveys out of a possible of 206 hospitals in three northwestern states.

A survey was developed and administered to provide hospital level assessments of five CI variables and six hospital performance measures. Differences between efficiency and effectiveness CI tool usage were also investigated. Differences in tool usage between large, medium, and small hospital size groupings were also investigated. A statistically significant difference was observed between small, medium, and large hospitals in their responses to this survey. There were 12 significant correlations reported between specific CI tools and individual hospital performance measures. Nine of these significant

correlations indicated poorer results for those hospitals that reported more frequently CI tool usage than those hospitals that did not.

For hospitals, the findings of this study indicated that the majority of the hypotheses did not support the strongly held and prevailing notion that the more individuals trained in CI tools and implementation practices the more the employee will be actively involved in continuous improvement. The results of this study also did not support some of the prevailing ideas related to the use of CI tools and implementation practices and performance improvement. Support was found to indicate that for the participants in this study, effectiveness tools were used more than efficiency tools. The results of this study also supported some previous research indicating that organizational size may be an important factor in the level of application of CI tools.

The Effects of CI Tools and Implementation Practices on Hospital Performance.

by

John W. Holliday

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Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

John W. Holliday, Author

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I want to especially thank my wife Valerie for all of her support, encouragement, love, and belief in me, even when I doubted myself that this was possible. Towards the end of this dissertation, Valerie had life threatening concerns, which would have devastated the normal person, but not only did she persevere she was able to provide the strength and courage I needed to continue. She is undoubtedly the most important thing in my life and without her I would not have had the courage to complete this long and arduous journey.

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1 Introduction

1.1 Research Motivation - Seven Issues Facing Hospital Administrators

Hospitals are facing a multitude of problems from steadily accelerating costs, treatment of the poor and indigent, nursing shortages, and public concern about patient care and safety. Industrial engineers, specifically engineering management professionals, are well positioned to help hospital leaders and administrators meet these challenges. Industrial engineers traditionally have led manufacturing organizations in their efforts to increase the effectiveness and efficiency of physical product delivery systems, often employing techniques to optimize cost while improving quality through process innovation and productivity improvements. Industrial engineers have played a pivotal role in implementing continuous improvement (CI) activities in manufacturing (Mizuno, 1990; Shingo, 1981). Seven issues facing hospital administrators identify the scope of this study, and are discussed below.

The first issue faced by hospital administrators is cost. The U.S. Department of Health and Human Services (2007) found that hospital expenditures for the U.S. have more than tripled. Specifically, costs have quadrupled rising from $494 million (USD) in 1985 to almost $2 billion (USD) in 2005. The Centers for Medicare and Medicaid Services' (CMS, 2006) projections indicate that annual expenditures will continue to rise for the next two decades, and reach almost $8 billion (USD) by 2025.

Accelerating costs for health services are even more significant when put into the larger economic context. The combined expenditures for medical research and health services are increasing at more than double the rate of the Gross Domestic Product (GDP) in the USA. In 1950, medical research was 0.08 percent of the GDP, and by 2000, this percentage had doubled. For this same period, costs for health services grew at a rate almost five times that of the GDP. The growth rate for health services tripled that of the GDP growth rate over this 50-year period (Ginter, Swayne & Duncan, 2006; see Table 1).

Table 1: U.S. Medical Research Expenditures and Health Care Services Expenditures as Percent of Gross Domestic Product in 1950 and 2000

	1950		2000		
	GDP $	Percent of GDP	GDP $	Percent of GDP	Percent growth
Medical Research	244	0.08	14,696	0.16	5923
Health Services	4,700	1.60	485,400	5.26	10228
Subtotal	4,944	1.68	500,096	5.42	10015
Total GDP	294,300		9,224,000		3034

Note. Dollar values in millions.

An increase in both charity and bad debt cases is another part of the issue facing hospital administrators that contributes to the escalating health care costs. In 2005, the number of uninsured people in the U.S. was estimated at over 46 million, which when coupled with charity and indigent care, raised significant cost issues for U.S. hospital administrators (Ginter et al., 2006). The Emergency Medical

Treatment and Active Labor Act of 1986 required all administrators of hospitals with emergency rooms to treat and stabilize any patient who arrives at their Emergency Department (ED) (Swayne et al., 2006). Hospital budgets must absorb the associated costs for the care of these individuals.

Charity and indigent care in Oregon amounted to a loss of approximately six percent of the gross patient revenues for 2005 (Oregon Hospital Report, 2006), with charity cases tripling between 2001 and 2005 (Oregon Hospital Report, 2006; see Figure 1). Charity cases rose from over $60 million (USD) in 2000 to $231million (USD) in 2005, an increase of 282 percent (Office of Oregon Health Policy and Research, 2006).

In Washington State, the trends are similar, and only slightly less dramatic. Charity cases almost doubled in numbers between 2000 and 2004. During this same period, the costs of charity cases rose from $258 million (USD) to $378 million (USD), an increase of only 47% (Washington State Department of Health, 2006).

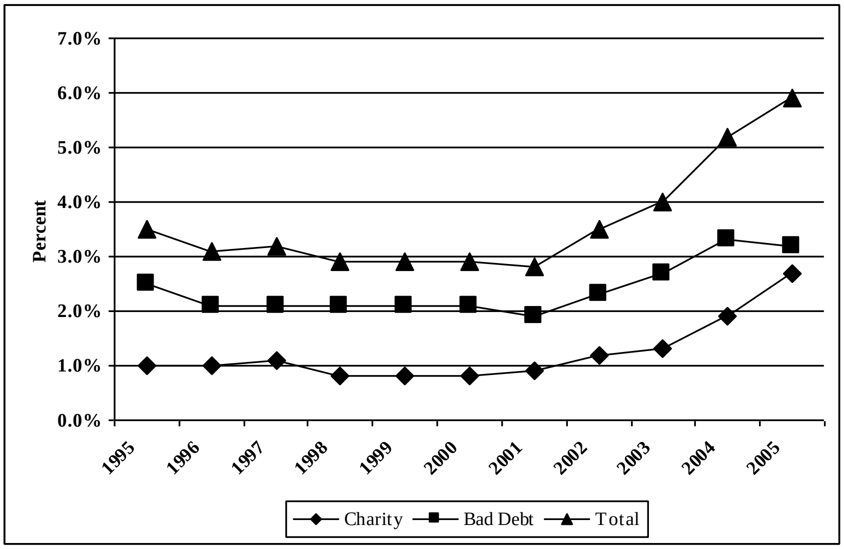

Figure 1: Uncompensated care for Oregon state hospitals

A second significant issue facing hospital administrators today is the shortage of registered nurses (RNs). The U.S. nursing shortage will number an estimated one million nurses by 2020 (HRSA, 2006). In 2006, there were shortages of approximately 118,000 RNs. This shortage of RNs equates to a nationwide vacancy rate of eight percent. By 2014, there will be approximately 700,000 new unfilled RN positions needed, which represents two-fifths of all new jobs to be created within the health care industry (Rosseter, 2008).

In Washington State, the RN shortage for 2006 was approximately 4,800, which accounted for 20 percent of all employment vacancies within the state. Over 49 percent of all RNs in Washington State are over the age of 47. Because of the aging population of the nurses, state officials project that this situation will worsen; within the next two decades, the majority of these nurses will retire leaving additional vacancies. Similarly, in 2005, Oregon faced a shortage of 1,800 RNs. In

Oregon, the annual projected demand of RNs is 1,200. The current replacement rate of RNs is only 1,100 per year, and thus, demand will outpace supply every year. Colleges and universities are stepping up activities to recruit educators to train additional nurses; however, these educators are predominantly being recruited from the same pool of nurses exacerbating the lack of trained nursing staff.

The loss of RNs as a result of dissatisfaction aggravates the issue of nursing shortages, and puts additional cost strains on the administrator's budget. The estimated cost to replace an employee is 30 percent of an employee's annual salary. Delnor-Community Hospital in Chicago saved approximately $800,000 (USD) annually by reducing turnover rate by seven percent, a reduction in turnover from 28 percent to 21 percent (Boehmer, 2006).

A third significant issue facing hospital administrators is the growing public concern about patient safety. Public concerns for patient safety reached new levels with the release of the 2001 Institute of Medicine's (IOM) text, *Crossing the Quality Chasm* (Institute of Medicine, 2001).

The IOM developed 13 recommendations for the overhaul of the U.S. health care system. Five of these recommendations (2, 4, 7, 10, and 12) highlighted the need for hospitals to implement CI activities with a focus on the delivery of health care, particularly in a hospital setting. One of the many items identified in the text was that on average, approximately 98,000 patients die annually in U.S. hospitals as the result of hospital clinical staff errors. Recommendation 2 specifically states that health care organizations should be safe, effective, patient-centered, timely, efficient, and equitable.

Nursing and other staffing shortages influence the quality of patient care. Fewer nursing staff to attend to patients places a larger patient load on the staff (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002). Needleman, Buerhaus, Mattke, Stewart, and Zelevinsky (2002) studied 799 hospitals in 11 states and found that fewer RNs translates into fewer hours of care that each patient receives per RN each day. Subsequently, patients experience more failures to rescue, more cardiac arrests, more cases of shock, and more cases of excessive blood loss.

A fourth area of concern for hospital administrators is patient satisfaction. Patient satisfaction is influenced by many factors, two of which are staff attitudes and timeliness of service (Atkins, Marshall, & Javalgi, 1996; Eilers, 2004; Guadagnino, 2003; Hyrkas, & Paunonen, 2000; O'Connell, Young, & Twigg,1999). Patient satisfaction is of major importance in the overhaul of the healthcare system in the U.S. (IOM, 2001). The timeliness of service has an effect on patient satisfaction. The longer the wait, the less satisfied the patient becomes (Bolus & Pitts, 1999; Trout, Magnusson & Hedges, 2000).

Waiting for the delivery of services has been the object of study by many disciplines, all with similar findings: people do not like to be kept waiting. The most congested areas for a hospital appear to be the Emergency Department (ED), laboratories, and clinics (Bolus & Pitts, 1999; Eilers, 2004; McCarthy, McGee & Boyle, 2000; Tom & Lucey, 1997; Trout, Magnusson & Hedges, 2000; White, 1999). Patients using EDs face longer wait times as a result of the increased usage by the uninsured and underinsured (Case et al., 2004; Olshaker & Rathlev, 2006). Delays in service translate into longer hospital stays, congestion in the waiting and service areas, delays in admittance, and added risk of hospital-acquired infections (Ulrich et al., 2004).

A fifth area of concern for hospital administrators is employee satisfaction, and the need to reduce the surrounding causes and effects associated with employee dissatisfaction. The cost ramifications of RNs' dissatisfaction have been identified above. However, the importance of staff attitudes cannot be underestimated, nor the effect of those attitudes on patient satisfaction. The interrelationship between employee satisfaction and patient satisfaction is beginning to emerge in the literature (Al-Mailam, 2005; Bedi, Arya & Sarma, 2004; Huff, 2007).

Studies investigating the effects of teams/involvement on employee satisfaction are associated with the upsurge in interest regarding employee satisfaction. The IOM Recommendations 4 and 12 highlight the need for increased collaboration among healthcare professionals and the importance of teams in promoting involvement and increasing employee satisfaction (Locke, 1970; Seecof, 2004; Sohal, Terziovski, & Zutshi, 2003; Spence et al., 2001). These IOM recommendations emphasize the need for cross-functional teams, work cells, quality circles, and self-directed work teams, all of which form the basis for employee involvement tools that are important to employee satisfaction. Teams are an integral part of CI activities (Dooley & Johnson, 2001; Feigenbaum, 1991; Ishikawa, 1985; Juran, 1988; Mizuno, 1988;

Shingo, 1985; Wedgewood, 2006). Lashinger, Finegan, and Shamian (2001) found a strong correlation between involvement and job satisfaction in a study of 600 nursing students. Research has shown that a positive relationship appears to exist between the number of departments involved in improvement projects and the outcomes of waiting times for rooms (Poole, 1998), error reduction (Carman et al., 1996), and customer and employee satisfaction (Ramalingam, 1996).

The IOM Recommendation 10 describes the need to overhaul the payment incentive system and pay for performance. The idea of reinforcing desired behavior to increase the likelihood of that behavior being repeated is a known relationship (Bandura, 1969). Pay for performance is an attempt to reinforce those performance-related behaviors desired by hospital administrators and identified as critical for the proper functioning of the hospital. Pay for performance acts as a reinforcer, and by definition, a reinforcer is a stimulus that produces pleasure (Bandura, 1969). Thus, pay for performance becomes a tool that hospital administrators can employ to shape the functioning of their organizations and improve employee satisfaction.

A sixth issue facing hospital administrators is the need to incorporate CI activities into the processes and procedures of their hospital’s daily routine. The IOM Recommendations 2 and 7 identified the need for health care process redesign, with emphasis on effective and efficient systems, the importance of the benchmarking of best practices, and increased accountability of staff for results through the use of metrics. Health care and manufacturing industries have used CI activities to improve the effectiveness and efficiency of processes and products for over 20 years with only minor success for healthcare. The health care industry, particularly hospitals, has not seen the dramatic level of improvement in costs and quality as those realized by the manufacturing industry. The health care industry has primarily used effectiveness tools, which are associated with quality and reliability of goods and services, for most of the past 20 years (McLaughlin & Kaluzny, 1999). In health care, the scientific study and analysis typically found in TQM and Six Sigma strategies, which integrate effectiveness tools, focused on effectiveness problems and solutions that fit closer to the model used by nurses and physicians in diagnosing patients.

Efficiency tools focus on the improvement in both the flow of materials and people through a facility. The goal for using efficiency tools is the reduction of waste (i.e., waste in time, waste in money, waste in movement, and waste in resources), all of which fall under the umbrella of efficiency tools (IOM 2001). Only within the last seven to 10 years have hospital administrators begun to see the importance of resolving efficiency problems through the use of efficiency tools. Because of the timing of this realization occurring only recently, a concern exists that improper framing of problems could lead to a limited, if not inappropriate solution set, resulting in no improvement, or at best sub-optimal improvement (Wickens et al., 2004).

An integral part of CI is the tools used to understand and improve processes and procedures. Related to this is the number of CI tools used in any given project. Studies have shown that when more CI tools were used, customer satisfaction was higher and costs were lower (Cua et al., 2001; Ishmail, Baradie, & Hashmi 1998). Shah and Ward (2003) studied the effect of a number of CI tools employed to reduce costs within a manufacturing site, and found similar results. Poole (1998) investigated the relationship between the number of CI tools and their effect on error reduction and turn times for patient rooms. As with the previously cited studies, Poole found that the more tools that were available for use, the more effective the interventions were in lowering error rates and improving wait times for patient rooms.

The seventh and last issue facing hospital administrators is training. The IOM Recommendation 12 emphasizes the need for increased CI training for hospital staff. Who should be trained and the importance of training to the success of CI projects is stressed in previous studies and reviews e.g. Argyris & Schon, 1996; Emison, 2004; IOM, 2001; Ishikawa, 1985; Kantor & Zangwill, 1991; Middel et al., 2006; Mizumo, 1998; Murray & Chapman, 2003; Rajagopalanh, 1998; Shingo, 1985; Zangwill & Kantor, 1998. Everyone who is going to participate in CI projects should be trained. However, the lack of empirical evidence, along with the increasing costs of training, raises questions regarding who and how many should be trained. There is growing evidence for the establishment of a threshold of trained individuals (Bullington & Bullington, 1995; Narasimhan et al., 1996; Rajagopalanh, 1998). This group of trained individuals would mentor other staff in CI techniques and tools. However, the threshold of trained individuals is unknown. It is not known if the threshold is five or 10 percent or more of the workforce, or whether or not the threshold varies depending upon the hospital size.

In summary, hospital administrators have an almost overwhelming set of challenges, in addition to seemingly conflicting and even mutually exclusive constraints (e.g., lower costs and improve quality). Industrial engineers, specifically engineering management professionals, can help hospital leaders and administrators meet these challenges. Industrial engineers have traditionally led manufacturing organizations in their effort to increase the effectiveness and efficiency of physical product delivery systems, often times employing techniques to optimize cost while improving quality through process innovation and productivity improvements. Within the sub-discipline of engineering management, the existing body of knowledge related to CI training, collaborative work systems (teams), and performance measurement systems are also of particular relevance. Research in these areas can potentially play an important role in helping hospital leaders and administrators address this complex array of issues.

This dissertation was the vehicle to analyze the use of specific tools in CI activities. The focus of this dissertation is on establishing a linkage between the understanding of CI activities in hospitals and the relationships between the use of effectiveness and efficiency techniques and tools.

1.2 Research Model and Hypotheses Development

Health care managers and industrial engineers working to improve the performance of health care systems have a wide array of CI tools and implementation practices from which to choose. To select the most appropriate CI tool, the type of organizational performance improvement needed must first be identified. Within the engineering management literature, and more specifically in the domain of performance measurement, one framework that exists for improving overall organizational performance is the balanced scorecard. The premise behind the balanced scorecard is that organizational performance must be evaluated across four areas: financial, internal operations, learning and innovation (employees), and customers. If an organizational focuses on a single performance area, the long-term ability for the organization to be successful will be compromised (Kaplan & Norton, 1998). This study used the balanced scorecard framework to identify a set of performance measures to ensure that the impact of the CI tools is understood, recognizing that some CI tools might lead to improved financial performance, whereas others might target the skill growth of employees as the primary performance improvement goal. Within health care, there is growing evidence that results from one area are tightly coupled with results in one or more of the other areas of the balanced scorecard.

The model illustrated in Figure 2 incorporates the seven issues described in the previous section of this chapter, including the balanced scorecard to organize the six dependent variables identified for study in this dissertation.

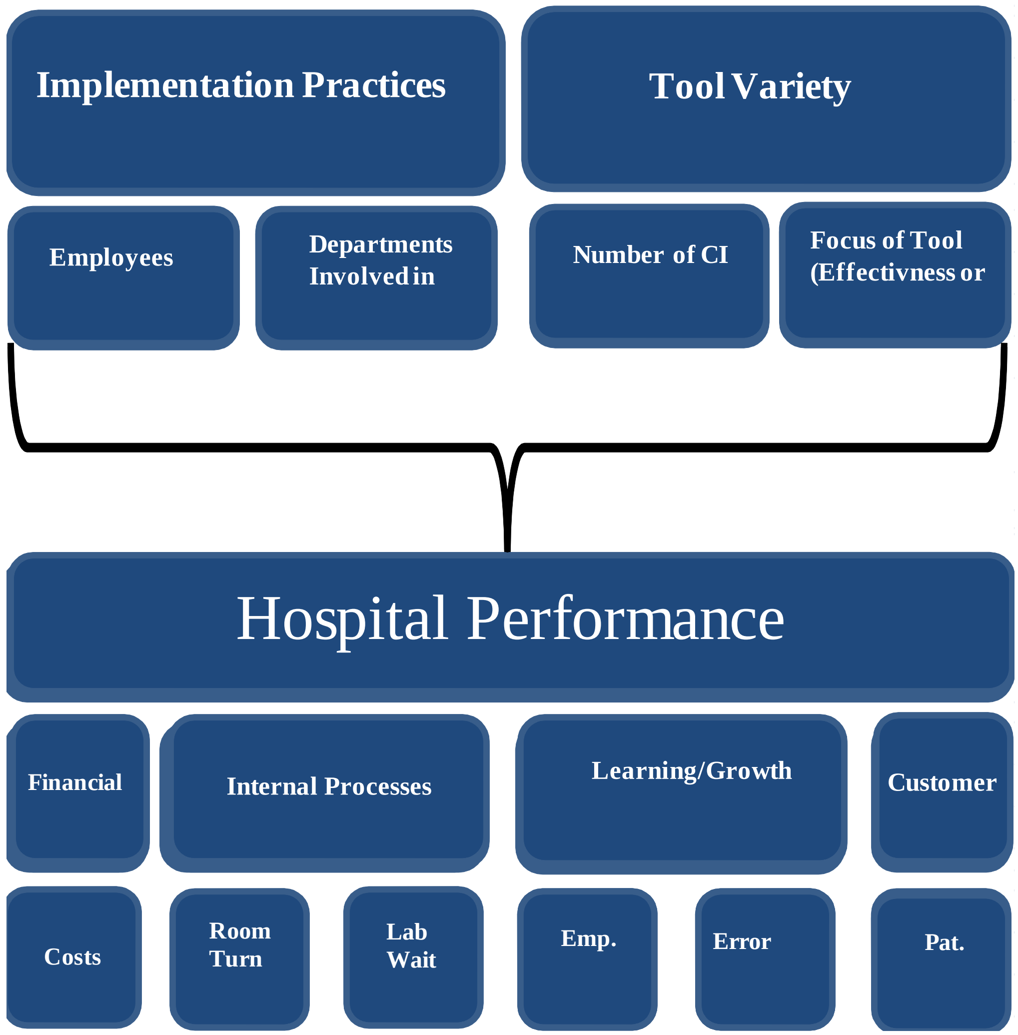

Figure 2: Research model

The implementation practices and tool variety represent the two main groups in which the five independent variables are found. Under implementation practices are the two independent variables, number of employees trained and departments involved. Under tool variety are the three independent variables, number of CI tools used, individual tool, and focus of tool used. These five independent variables i.e., employees trained, departments involved, total number of tools used, individual tool used and focus of tools, were identified from the seven issues facing hospital administrators.

These independent variables were hypothesized to have an effect on the hospital performance as identified in the six dependent variables i.e., room turn time costs, lab wait time, error reduction patient satisfaction, and employee satisfaction. These dependent variables were also identified from the seven issues facing hospital administrators. The four groupings directly above the dependent variables represent the four categorical metrics of a balanced scorecard.

The five research questions selected for this study were identified by looking at the gaps in understanding that currently exist, with the ultimate goal of being able to provide managers and the industrial engineering professionals in health care with empirically-based recommendations for selecting appropriate CI tools and for implementing these tools. Distilled from the model, these research questions represent the primary focus of this dissertation.

1. Does the number of full-time employees trained in CI tools effect the hospital's performance?
2. Does the number of departments involved in CI projects effect the hospital's performance?
3. Does the number of tools used in a CI project effect the hospital's performance?
4. Do hospitals only use either effectiveness or efficiency tools in CI projects?
5. Does the use of a particular CI tool in a CI project effect the hospital's performance?

The hypotheses developed from the research model as well as from a review of literature are summarized next.

H_1: The number of full-time employees trained in CI tools has an effect on:

H_{1a} wait time for lab results.
H_{1b} patient costs/day.
H_{1c} time to prepare a room.
H_{1d} reduction in number of reportable errors.
H_{1e} overall rating for patient satisfaction for the hospital.
H_{1f} overall rating for employee satisfaction for the hospital.

H_2: The number of departments engaged in CI Projects has an effect on:

H_{2a} wait time for lab results.
H_{2b} patient costs/day.
H_{2c} time to prepare a room.
H_{2d} reduction in number of reportable errors.
H_{2e} overall rating for patient satisfaction for the hospital.
H_{2f} overall rating for employee satisfaction for the hospital.

H_3: Tool variety, as measured by the total number of CI tools used in CI projects has an effect on:

H_{3a} wait time for lab results.
H_{3b} patient costs/day.
H_{3c} time to prepare a room.
H_{3d} reduction in number of reportable errors.
H_{3e} overall rating for patient satisfaction for the hospital.
H_{3f} overall rating for employee satisfaction for the hospital.

H_4: Hospitals are equally likely to use effectiveness and efficiency tools in CI projects.

H_5: The use of individual CI tools in CI projects has an effect on:

H_{5a} average wait time for lab results.
H_{5b} average patient costs/day.
H_{5c} average time to prepare a room.
H_{5d} reduction in number of reportable errors.
H_{5e} overall rating for patient satisfaction for the hospital.
H_{5f} overall rating for employee satisfaction for the hospital.

1.3 Limitations

The review of literature produced several ancillary and possibly related variables. One variable identified in previous research as a possible explanatory variable for successful CI projects was hospital size (as measured in number of licensed beds). While findings for previous studies were inconclusive, hospital size information was collected for all of the hospitals participating in this research, enabling testing for impact related to hospital size.

2 Literature Review

2.1 Introduction

2.1.1 Theoretical underpinnings of CI

To understand the theoretical underpinnings of CI it is necessary to review the three key CI principles important to any organization. The first key CI principle is the idea of never-ending improvement; to view improvement as a journey, not a destination. The original work of Shewhart in 1939 is one of the best representations of this idea (Figure 3).

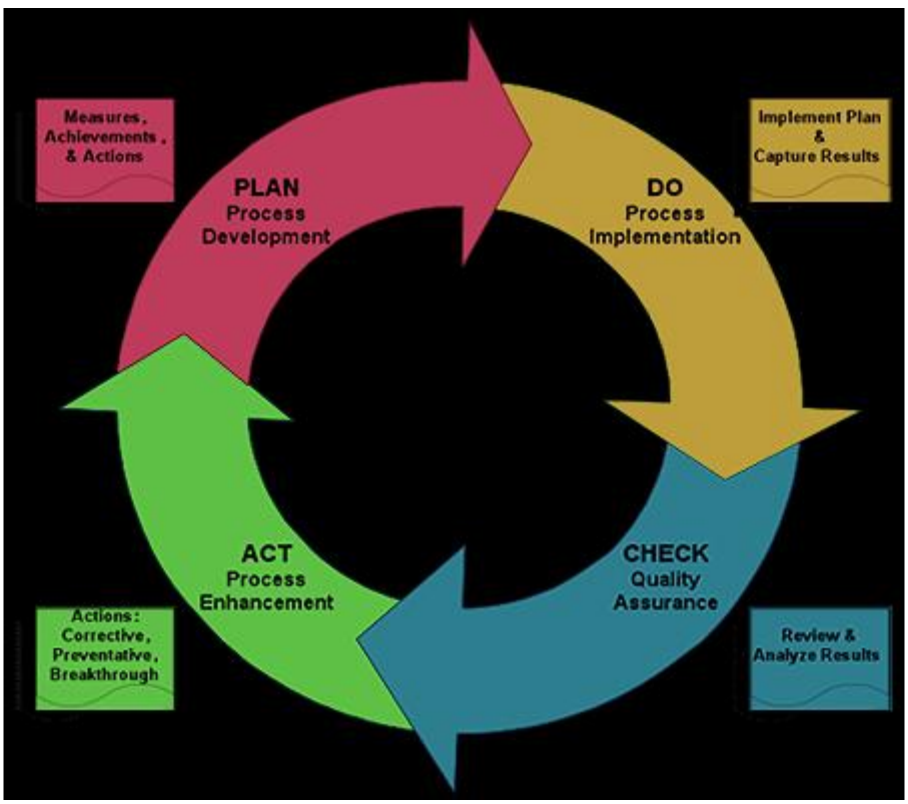

Figure 3: Shewhart Circle Representing Continuous Improvement Cycle

The circular representation is divided into quarters, and each quarter is labeled as Plan, Do, Check, and Act. The quarters represent the necessary activities needed to drive continuous improvement. The circle express the idea of a continuous path with no beginning and no ending. The first quarter, “Plan,” is the identification phase in which the team selects a variable to improve. The purpose of the second quarter, “Do,” is to execute activities determined to effect change in the variable selected in the “Plan” phase. The third quarter of the circle is the “Check” phase, when the results of the “Do” portion are evaluated and compared to the original performance. The fourth quarter is the “Act” phase, which evaluates the work of the previous three quarters, determines if any course corrections are needed, and then this information is fed back to the “Plan” phase to begin a new cycle of improvements (Mizuno, 1990).

The involvement of workers in decision processes of products and process improvements is the second principle of CI (Ishikawa, 1985). The worker has the necessary knowledge base for developing continuous improvement plans, and therefore, employee involvement in decision making should be encouraged (Demming, 1982 Ishikawa, 1985; Juran, 1988; McLaughlin & Kaluzny, 1999; Mizuno, 1990). Employee involvement has taken many forms. Three of these are quality circles, self-directed work teams, and work cells (McLaughlin & Kaluzny, 1999; McShane & Von Glinow, 2005; Shingo, 1985).

Employee involvement is believed to increase when the employee feels that their ideas are valued and respected (McLaughlin & Kaluzny, 1999; Shingo, 1985). Involvement and employee satisfaction have been positively linked together (Locke & Latham, 1990). A satisfied employee is more motivated to make suggestions and improve the processes (Shingo, 1985). Training of the worker is thought to provide the worker with an enhanced working experience and improve employee satisfaction, thus suggesting a cycle of satisfaction and involvement. Therefore, the more employees that are satisfied, the more likely they are to participate in CI activities (Shingo, 1985). Demming (1982) believed that training was a key element that was both important and necessary in order to drive CI in both product and process improvements.

The last key principle in the theoretical underpinnings of CI is respect for the customer and concern for their satisfaction with the product or process. Listening to the needs of the customer and translating those needs into product and process improvements are integral to CI activities (Deming, 1982; Mizuno; 1990, Ishikawa, 1985; Shingo 1981, 1985). The CI of products and processes is pointless without the customer to purchase those goods and services. Customer satisfaction is believed to increase customer loyalty and continued patronage (Bolus & Pitts, 1999; Guadagnino, 2003; White, 1999). Additional information is presented throughout this chapter to expand on the three CI principles. The next section, Prologue, outlines the balance of this chapter, the literature review.

2.1.2 Prologue

In reviewing the CI literature on health care, a large portion of the body of knowledge was applied research. For the most part, the applied research concentrated on the same six dependent variables identified for study in this dissertation. These were error reduction, costs, wait times, bed/patient room turn times, patient satisfaction, and employee satisfaction. However, most researchers examined each variable individually, which did not provide insight into any interactive effects or tradeoffs in improvements among the variables that may have been necessary to achieve their successes. Previous work provides a foundation for understanding CI practices and any apparent effect CI activities may have had on specific dependent variables.

This chapter also highlights the previous research findings associated with the five independent variables chosen for study i.e., employees involved in the CI effort, and departments involved with the CI effort.

The section begins by presenting a brief background of the use of CI in health care. Next, each of six dependent variables are defined, followed by a more detailed discussion of each of the six dependent variables, and how each of the hospitals that were studied used the five independent variables to produce changes in these dependent variables. The chapter concludes with an analysis of the relationship between the six dependent variable areas and the five independent variables, the limitations of the current body of research, and how the present study goes beyond the previous research to provide additional insight into possible interactive effects.

2.2 CI in Health Care

2.2.1 Background

Over the last two decades, increased emphasis has been placed on the study of CI efforts within hospitals. The evidence of this increased emphasis can be found in the number of studies that were conducted and summarized during this time period. Two models of CI dominated the research (i.e., effectiveness and efficiency). The effectiveness model is represented by TQM and Six Sigma, and the efficiency model is represented by Lean Manufacturing techniques, with increasing interest in patient through-put and increased revenues. Both of these models were defined in Chapter 1; however the definition of CI has not been addressed, and thus deserves attention. Three definitions for CI are given below, two from health care and one from a government organization. At the conclusion of the definitions, there will be a summary of the salient points and a discussion of how these were incorporated into the operational definition of CI used in this research.

2.2.2 Definitions

2.2.2.1 CI

The following three definitions were chosen because they represent three different institutions from three English-speaking countries, each institution and country having similarities and differences to each other but form the bases of understanding and usage for continuous improvement used in this dissertation.

Medical University of South Carolina (MUSC) defines CI as an approach to quality assurance methods by emphasizing the organization and systems. When quality is viewed from a systemic approach, processes become the target of improvement activities rather than the individual (Reason, 2003).

The Health Department of the province of New South Wales, Australia, defines CI in terms of a guiding belief in organizational ethos. By seeking user requirements and ensuring the organization is capable of meeting those demands, the quality management team is able to focus on improving processes through which the services or products are delivered.

The last example is from the Competitive Business Strategy Group of the Canadian Government. That organization defines CI as a concept, one in which there is always room for improvement. It is through the commitment to CI in operations, processes, and activities that customer requirements can be met in an efficient, consistent, and effective manner.

In summary, CI is the commitment to a journey in search of excellence, within operations, processes, and activities, by incorporating the elements of efficiency and effectiveness in a consistent manner. The remainder of this section defines the six dependent variables, error reduction, costs, wait times, bed turn times, employee satisfaction and patient satisfaction.

2.2.2.2 Error

Error, as defined by James Reason (2003), is " …a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency" (p. 23). A sequence of planned actions could fail to achieve the desired results, either because the actions were flawed or because the plan itself was inadequately defined. Thus, two more definitions are proposed by Reason to account for these possibilities: "Slips and lapses are errors which result from some failure in the execution and/or storage stage of an action sequence, regardless of whether or not the plan which guided them was adequate to achieve its objective" (Reason, 2003, p. 24). The other definition refers to failures in judgment. As Reason states, "Mistakes may be defined as deficiencies or failures in the judgmental and or inferential process involved in the selection of an objective or in the specification of the means to achieve it, irrespective of whether or not the actions directed by this decision-scheme run according to plan" (Reason, 2003, p. 24). The definition used for this study is that an error is an action taken to effect a desired result, but that fails to deliver that desired result. This definition incorporates slips, lapses, and mistakes. An example of an error would be going to your bedroom to retrieve your car keys and then returning without them or returning with a glass that was in the bedroom. Another example is the belief that you need to turn left while driving to the store, when the correct action was to turn right and failing to correct the mistake until some time passes because you are convinced that turning left was the correct action.

2.2.2.3 Costs

Costs are defined as expenses that are incurred for the treatment of a patient while in the hospital and are measured as costs per patient days. Costs were represented in thousands of dollars (K$) in this dissertation.

2.2.2.4 Wait times

Wait times are when a patient anticipates a good or service being delivered, but does not receive that good or service as scheduled. Riggs (1976) states that waiting for services would never exist if the average arrival rate was less than the average service rate. Therefore, waiting time is the duration of time from the point of patient arrival to the time service is delivered.

2.2.2.5 Bed turns

Bed turn time is the duration of time that is required for a housekeeper to prepare a room for a new patient. This includes, but is not limited to, washing the floor, cleaning the bathroom, removing linens, sterilization of the mattress and frame, placing clean linens on the bed, and sterilizing the countertop, phone, and other devices that the previous patient may have touched. The time for this activity begins when the nurse places a call to coordinator of housekeeping alerting the coordinator that a room has been vacated and requires cleaning.

2.2.2.6 Employee satisfaction

Herzberg (1959) defined employee satisfaction in terms of two separate factors, motivational factors and hygiene factors. Motivation factors are those tangible and intangible stimuli that go into developing a feeling of fulfillment, growth, and esteem within employees. These are balanced with a set of dissatisfiers, identified as hygiene factors, and are typified by poor working conditions, unsafe practices, and inappropriate pay (Herzberg, 1959). In order for an employee to have satisfaction with work, hygiene factors must be eliminated first (Shortell & Kaluzny, 2000). Smith, Kendall and Hulin (1965) on the other hand, argue that job satisfaction is a multi-dimensional construct, composed of varying degrees of satisfaction with different elements of the job (e.g., pay, workplace, management etc). By combining Smith, Kendall and Hulin’s definition of a multidimensional construct with Herzberg's theory of employee satisfaction, the definition for this study becomes a multidimensional construct where motivation and hygiene factors are associated closely with varying degrees of satisfaction regarding different elements of the job.

Many hospitals are unsafe for employees and represent examples of the lack of Herzberg's hygiene factors (1959). Hospital staff is constantly faced with; attacks by patients, exposure to diseases, unsafe practices (e. g., lifting heavy patients) and administering medication or sedation to uncooperative patients (Duncan, Estabrooks, & Reimer, 2000; Lipscomb & Love, 1992; McPhaul & Lipscomb, 2004).

2.2.2.7 Patient satisfaction

Patient satisfaction is, "…the evaluation rendered that the experience was at least as good as it was supposed to be" (Hunt, 1977). Alternately, if the service or product meets or exceeds expectations, then the consumer (patient) is satisfied (McLaughlin & Kaluzny, 1999). In both of these definitions, the main point is that satisfaction is subjective and based upon the expectations of the person at the time of service. Thus, patient satisfaction was defined for this study as a subjective judgment regarding the level of service received, compared to the level of service expected.

The next section begins with a brief description of Total Quality Control (TQC), followed by the definition of a balanced scorecard, and concludes with a summary of CI activities in hospitals. Following an explanation of Table 2, each of the dependent variables is examined in greater detail.

2.3 Six Dependent Variables

Shingo (1985) described how Deming and Juran introduced TQC to Japan in 1951. During the initial phase of implementation, it was important to involve the workers on the floor in development and goal setting for CI activities. However, as CI implementation activities grew within organizations, it became exceedingly important to involve technology, finance, marketing, and personnel departments in CI implementations. For the Japanese, TQC meant total involvement of all employees in CI activities throughout the entire organization. Company-wide success was dependent upon the company-wide incorporation of CI activities (Shingo, 1985).

A concern emerged within industry that it appeared that in the process of resolving one problem other problems were neglected. This was affecting the entire business model. If a problem in finance was corrected by increasing the number of goods sold, then operations would be put under additional strain to produce additional products, which would strain the production of the products, the delivery of raw goods and the inspection and testing of completed products. This additional strain often resulted in poorer performance within these other departments.

Kaplan and Norton (1998) suggested that the use of the balanced scorecard of metrics from four key areas within an organization forced management to consider the implications of their decisions. Decisions that were designed to make improvement in one area may result in regression in one or more areas. Thus, by using a balanced view of the organization when implementing changes, one could reduce the risk of decreased performance in some areas, and increase in performance in others.

This problem exists in the health care industry and especially large facilities like hospitals. The CI programs in hospitals have been seen as a means of change for over 20 years; however, these programs do not seem to have produced an overall improvement in patient care (IOM, 2001). Several agencies have, in the last 10 years, recommended areas for hospital improvement, including patient safety, employee morale, and reduction in costs (AHA, 2004; CMS, 2008; IOM, 2001).

This study used the IOM recommendations and review of the current literature to develop both the dependent and independent variables included in this study. In the following portion of this chapter, each of the six performance measures is presented along with the pertinent literature used in developing the hypotheses for this study. The purpose of this was to establish a foundation to inform the development of the research questions. Table 2 summarizes the research, cited in the remainder of this chapter, based on the six dependent variables chosen for the study along with three of the independent variables (Number of Trained Employees, Number of Departments, and Tool Focus).

Table 2: Summary of the Literature Reviewed by Dependent and Independent Variables

	Independent variables		
	CI Practices		Focus of Tools
Dependent variables	Employees	Departments	Effectiveness vs. Efficiency vs. Ind. Tool
Wait times	Primarily nurses and physicians from the same departments	Usually 1-2 departments (ED & Lab.)	Mostly effectiveness tools with some efficiency tools but not labeled
Costs	Single department representation usually on 1-2 member teams with a sub-contractor	Usually 1 department and a sub-contractor	Mixed: both efficiency effectiveness tools used
Bed turn times	Usually consultants and 1-4 individuals from the hospital	Primarily 1 usually housekeeping	Effectiveness tools
Error reduction	Cross-functional teams 2-7 members	Cross-functional teams usually 2-3 departments	Effectiveness tools mostly used
Patient satisfaction	100 + employees cross-functional teams	Multiple departments	Effectiveness only
Employee satisfaction	100 + employees cross-functional teams	Multiple departments	Mostly effectiveness tools

The purpose of Table 2 is to provide a quick and concise picture of the related research reviewed for this study. The independent variables of interest to this study are listed across the top of the table. The dependent variables are along the left side of the table. Within each cell is a summary of the way that the independent variables have been found to effect change on the dependent variables. For example, the intersection of the row “Error Reduction,” and the column “CI Practices,” indicates that in previous research effectiveness practices were used more often than efficiency practices. Overall, the dependent variable of error reduction was impacted with the use of effectiveness practice i.e., cross-functional teams with an average membership of between two and seven members. “Bed Turn Times” were found to typically involve only one department (housekeeping). Table 2 highlights the variety of approaches to improvement that have been used and studied. In addition, previous studies based on the size of the facility have not been directly correlated to improved results. The following section provides a detailed analysis for each of the dependent variables and the independent variables, and concludes with a summary of the salient points.

2.3.1 Wait times

Wait times have been associated with patient satisfaction; the longer the wait time, the less satisfied a patient becomes. Wait times in EDs all over the U.S. have been increasing throughout the last decade (Kennedy, 2004; Trout et al., 2000). Between 1997 and 2004, the median emergency room wait times for patients increased 36 percent, however, the wait for patients with Acute Myocardial Infarction (AMI) frighteningly increased by 150% during the same time period (Wilper et al., 2008). Of the 815 patients admitted to U.S. hospitals for AMI between the years of 1997 and 2004, 25 died in the ED (Wilper et al., 2008).

Two results of longer wait times in EDs include patients leaving without treatment and the diversion of ambulances to other facilities (Kennedy, 2004; Trout et al., 2000). Arendt et al. (2003) studied the length of wait times and the number of patients that leave without treatment. The authors found that when the time to wait decreased, the number of patients leaving without being seen also decreased; inversely, as time increased, the number of patients leaving without being seen increased.

In another study that measured the effects of longer wait times, McCarthy et al. (2000), at the Royal College of Surgeons in Dublin, Ireland, sampled 500 patients regarding their wait times at two outpatient clinics. The results showed that when the patients wait times ranged from zero to 270 minutes, 64 percent of the patients rated the waiting times at the clinic as unsatisfactory pointing to the long wait time as the reason, and the longer the wait, the stronger the dissatisfaction that was expressed by the patients (McCarthy et al., 2000).

The VHA, a large network of community-owned health care systems covering 47 states and the District of Columbia, reduced their ED wait times through the use of CI techniques. A multidisciplinary team was formed to identify ways to reduce wait times for patients. The team used brainstorming and process mapping to identify steps within the admitting process to target for change. Current process steps that were identified as non-value added were eliminated, and the process was redesigned. As part of the process changes, two triage nurses were stationed at the front end of the admittance process, which was determined to be where the greatest bottleneck occurred. With the new process, the nurses admitted patients, assigned an account number, and ordered lab work. In the original process, these steps would have occurred after the patient was admitted and dispatched to a waiting room, where they would await the triage nurse who would then assign an account number and order the lab work. The new process reduced the wait time for patients to an average of between 30 to 60 minutes from over a 90-minute average wait. In addition, the patient waiting area was eliminated, which provided additional space for more beds and eliminated the pileup of patients (McGrayne, 2004).

Kuell (2004) reported on the efforts of the staff at First Health Moore Regional Hospital, located in Pinehurst North Carolina, to reduce the wait time for patients in their ED. A multidisciplinary, self-directed work-team identified bed availability and times to place a patient in a bed as the dependent variables needing improvement. The team, comprised of ED and inpatient nurses, developed a signaling method to reduce both the first lag time from the bed being ready until the clean bed alert was sent out and the second lag time from when the clean bed alert went out until a patient filled the bed. This new signaling method resulted in a reduction in the first lag time on average of five minutes, and a reduction in the second lag time to within an average of 30 minutes (Kuell, 2004).

In a postscript to this study, it was noted that the self-directed work team continued to meet regularly to work on other issues to facilitate faster transfers of patients out of ED. In addition, another self-directed work team was formed with ED nurses, admitting staff, recovery, and catheter lab personnel to improve patient flow into and out of these areas (Kuell, 2004). This second team was a spin-off of the first team, and came after a review of the successes of the first team.

Woitas and Willemsen (2004) studied the ED at North Memorial Medical Center, located in Robbinsdale Minnesota, is a large hospital with 518 beds. A multidisciplinary team of ED nurses and lab technicians was formed to study the causes of wait times for lab results. The team was trained in Six Sigma methodology and used the five steps of DMAIC (Define, Measure, Analyze, Initiate and Control) to study wait times. The team found that the time to notify the phlebotomist was delayed because notification came only after the patient had been admitted and was then diagnosed by the nurse as needing lab work. The team noted that patients exhibiting specific behaviors and symptoms would usually need the same types of lab analysis. Thus, the team created a checklist identifying those symptoms to expedite the admittance, diagnosis, and notification of the phlebotomist. Also, the team created a standard cart of materials for the phlebotomist to use for the ED calls. Under the new procedures and using the checklist, as soon as the patient was identified as requiring lab work, the nurse notified the phlebotomist. During the time the phlebotomist traveled to the ED with the standard kit, the nurse completed the check-in process. After the phlebotomist arrived, the necessary samples were gathered and then sent directly to the lab, because the patient had already been admitted and given a patient ID. The results indicated a reduction of wait time from 46 minutes prior to the initiation of the changes to 16 minutes after the changes (Woitas & Willemsen, 2004).

The administration at Saint Joseph's Hospital, a small 22-bed facility in Lexington Kentucky, formed a team of physicians and nurses to investigate what was considered long wait times for screening tests. The team used brainstorming techniques to determine which type of tests could be initiated at point of care (POC). This similar method has been used in industry by locating the testing of a product near assembly, and has proven successful in both reducing production times and providing faster feedback to the assemblers. The self-directed work team decided upon the appropriate screening equipment, purchased the equipment, and implemented the new process. Though results indicated a reduction in screening time to 20 minutes, the pre-intervention statistic for screening was not provided. Therefore, it is difficult to identify how dramatic the 20-minute screening time may have been. Two outcomes, not sought after but noted, were an increase in communication between physicians and nurses and increased patient throughput, but actual measurements to substantiate those increases were not provided (Swinford, 2003). However, this study does suggest that a multidisciplinary self-directed work team can produce improvements in a small hospital setting using CI practices.

In all of the studies mentioned, the use of CI tools facilitated changes thought to improve patients wait times. The teams were primarily centered in ED and composed of the necessary ancillary participants from allied departments. The successes documented in these studies, indicate that CI efforts can facilitate change in the length of wait times in EDs. One of the main contributors to the lack of available beds has been thought to be the time to turn a dirty room into a room ready for a new patient. The shortage of beds has also been attributed to increased instances in which patients have been diverted to other hospitals.

2.3.2 Hospital Costs

Hospital service price, as measured by the Consumer Price Index (CPI), is a seasonally adjusted annual rate. The price for six months, ending February 2010 showed an increase of 7.6 percent (BLS, 2010). Compared to other product price growth indicators, medical services grew at twice the rate in 2003 (CMS, 2004). Health care spending increased by $621 billion between the years of 2000 to 2004. In 2007, $2.2 trillion was spent on health care in the U.S. (Senior Journal, 2008). In the U.S., the ratio of dollars spent on health care costs to the U.S. GDP is greater than any other developed country in the world. Therefore, citizens on average pay more for medical care in the U.S. than citizens pay for medical care in Europe, Canada, Australia, etc.

In response to the IOM (2000), hospitals have launched projects to reduce costs and eliminate waste. For example, St. Francis Hospital & Health Center in Illinois reduced discharge times from 2.7 hours to 1.2 hours. A reduction in discharge times has shown a corresponding increase in available beds, which can contribute to more patients getting admitted, and increases in revenue (Hamilton et al., 1994). In another example, the Virginia Mason Hospital in Seattle, Washington, reduced delays in surgery by 64 percent with corresponding increased patient flow. Children's Hospital of Boston Massachusetts is an example of how hospitals have eliminated waste to improve costs. The staff reduced waiting time for completion of infant's blood work by 62 percent. By reducing wait times, the opportunity for greater throughput was provided. With greater throughput, the opportunity for improved cash flow was possible.

The Swedish Medical Center in Seattle, Washington, a large facility with 1,245 licensed beds, formed a team in their environmental services group to improve the time to clean and return patient fluid re-circulating pumps from servicing. The team used Lean Manufacturing practices to identify and define opportunities for improvement (though specific practices were not defined). The study identified brainstorming as one of the methods to determining improvements and redefining activities associated with the operations of cleaning the patient pumps. The results of these efforts were a reduction in the cost to clean each pump, from $12.65 to $0.65. The associated time to clean the pumps was reduced from 21 hours to 34 minutes after the CI activity (Paige, 2005).

Two medium-size facilities, one in Missoula, Montana (Community Medical Center, 146 beds) and the other in Appleton, Wisconsin (Thedacare, 152 beds), reduced costs associated with inventories. Both hospitals used Lean Manufacturing practices to accomplish the savings. The Community Medical Center used point-of-use stocking methods to supply the surgical units and saved $7,900. An added benefit was the reduced number of unit calls for supplies from 32 per day to two per week (Paige, 2005). Thedacare of Appleton also used point-of-use stocking and developed a signaling system to provide a reorder point alert for materials (Paige, 2005). Reorder points were established based upon consumption rates for the materials and the lead time required to order and restock the materials. Thedacare used a color system: green indicated sufficient materials, and yellow signaled a need to reorder materials. The author of this study identified that a $500,000 savings in total supplies was documented (Paige, 2005).

Another study focused on reducing the costs of cardiac surgery and was conducted at the University of Alberta Hospital, in Alberta Canada. This is a teaching hospital with 650 licensed beds and treats more than 700,000 patients annually. A multidisciplinary team was formed to study the process. The team found opportunities for improvement within the policies and procedures for the operating room and intensive care unit. To test the hypothesis, the team used pre-intervention and post-intervention comparisons of 98 patients who were randomly selected. The improvements seen were the elimination of non-value-added steps and modifications resulting in patients moving more expeditiously into the ICU. In addition, the more expeditious transfer of patients to less costly regular units, and nurse self-scheduling for ICU coverage improved the accuracy of staff matching to patient load (Hamilton et al., 1994).

Information on pre-hospital wait, pre-operative hospital length of stay, total operating room time, surgical time from incision to closure, ICU length of stay, and post-operative length of stay were collected and analyzed. A student t-test was used to compare both groups. The results indicated a decrease in wait times of one hour. The total length of stay was reduced by three days, and there was a decline in hospital costs per patient of $4,000 (Hamilton et al., 1994).

One of the main contributors to the lack of available beds has been thought to be the time to turn a dirty room into a room ready for a new patient. The shortage of beds has also been attributed to increased instances in which patients have been diverted to other hospitals. The next section will discuss the studies associated with reducing the turn times required for room preparation.

2.3.3 Bed turn times and occupancy

U.S. hospitals declined in number from 5,384 in 1990 to 4,895 in 2003, equating to a decrease of eight percent. The number of hospital beds fell from 925,000 to 820,000, which translates to a nine percent reduction in total bed count. From 1996 to 2002, ED visits increased nationwide by 14 percent (McCarthy, 2008). With the reduction in beds, the increased number of visits places an additional strain on hospital EDs and ICUs to find alternative beds within the hospital for patients.

The results of fewer available beds are increased diverts and longer times in the ED and the ICU. Maintaining patients in the ICU and ED is expensive, because there is a higher proportion of nurses and doctors per patient. An inability to transfer patients from the expensive EDs and ICUs where the patient nurse ratios are low to the most cost-effective floors where the patient nurse ratios are higher ultimately increases the patient’s costs. Reduced revenues are experienced when hospitals are forced to divert patients to another hospital for care, which is of great concern to hospital administrators (Butcher, 2005; Haraden & Resier., 2004).

Sager and Ling (2007) reported on the use of Six Sigma tools to improve the time required to discharge patients and thus increase the number of beds available for occupancy. Our Lady of the Lourdes Regional Medical Center is a medium-size New Jersey hospital with 200 beds. A 15 member cross-functional team was selected to identify the steps to prepare a room for a new patient and to improve the process. Among the tools used by the team were Ishikawa diagramming, Pareto analysis, and process mapping. The overall time to prepare a room was reduced from 267 minutes to 235 minutes, for a reduction of 12 percent. Variability within the process of discharging a patient was reduced from 318 minutes to 168 minutes. Projected cost improvements of $198,000 annually were expected in housekeeping (Sager &Ling, 2007). However, the largest lead-time was for the doctor to write the discharge notice, which was not addressed by the team. The time for a physician to write a discharge order once the patient was verbally released averaged over 160 minutes out of the total 318 minutes of wait time (Sager &Ling, 2007). By not focusing upon the major concern i.e. physician time to write discharge notices, the study failed to achieve more significant results.

Another study to improve the bed turns involved a for-profit consulting firm, Healthcare Excellence Institute, and a large, unnamed hospital. An interdisciplinary team of housekeeping, nursing, admitting, and unit clerks was formed to reduce the bed turnaround time by 30 percent. The team used several tools from Lean Manufacturing and Six Sigma, including data collection analysis and charting, process mapping, and timing operations. After the data were compiled and analyzed, it was determined that from the time the patient was ready to be discharged until the patient was actually discharged took between five and seven hours. It was noted that the room cleaning process was approximately 30 minutes. The team focused on the other four and a half to six and a half hours. The team determined that improvements were needed in the floor layout of the nurses' station to improve throughput and flow. In addition, the team decided that tracking the process steps during discharge was needed to reduce the amount of time it took to discharge a patient. The results indicated an immediate reduction of time to discharge by two hours, which equates to a 30 percent reduction, and approximately 10 extra beds per day (Healthcare Excellence Institute, 2010).

Alina Hospitals and Clinics, a large system of 11 hospitals and 42 clinics, began investigating bed turns, diversions, and patients who leave without being seen. Using the Shewhart Cycle of Plan Do Check Act (PDCA) and employing a collaborative effort with multi-departmental staff, they began with meetings to clarify metrics and identify roles and responsibilities. In 2006, all 11 hospitals launched interdisciplinary teams to improve patient flow. The staff compared the metrics of 2005, which was prior to the interventions, to metrics following interventions in 2006. The results of this comparison indicated that improvement was seen. As an example, in 2005, in one of the hospitals with 400 beds, they experienced 5.73 diverts per month. In 2006, that number dropped to 1.5 diverts per month with similar improvements observed in other hospitals (Ohare & McElroy, 2007). Most of the attempts to reduce wait-times did not address the root cause and analysis was limited to a few studies. The need for continued investigation into improving the turn times for discharges using analytical tools is evident from this review.

2.3.4 Error reduction

Iatrogenic error is any adverse event (any side effect) associated with any medical practitioner or treatment. The practitioner need not be a physician, but rather might be a nurse or a radiology technician, or any other health care worker encountered in hospitals (Webster's Medical Dictionary, 2003). There is reluctance in the U.S. and other Western countries to report errors, because of threat of increased liability faced by the individual and hospital. The IOM, in order to promote error reporting, is de-emphasizing the focus of blame upon the individual and encouraging a view of errors as a system problem. The first area to be discussed related to error reduction is pharmacological improvements.

2.3.4.1 Pharmacological studies

Medication errors are the most common cause and a major component of medical errors in U.S. hospitals, affecting 3.7 percent of patients. Data suggest that 11 percent of medication errors in hospitals were pharmacy-dispensing errors, related to the wrong drug dispensed to patients or the incorrect strength of the medication. A study on medication errors in the U.S. indicated that 7000 deaths of 1.5 million medication errors (Harrison, 2006). One study by Esimai (2005) identified 10 opportunities for error reduction related to medication errors in a medium-size hospital. The hospital employees established a cross-functional team to identify and reduce pharmacologically related errors using Six Sigma tools. The teams were comprised of employees with floor experience in various associated processes (i.e., order filling, prescription transcription, and records administration).

Ten categories of errors were identified: (a) additional instructions superfluous to the prescription order, (b) wrong dosage, (c) wrong drug, (d) duplicate orders, (e) frequency of dispensing, (f) omissions of medication, (g) discontinuation order not carried out, (h) orders not received, (i) incorrect medication prescribed for patient, and (j) wrong dispensing method identified. Pareto analysis was used to identify the top four categories: order not received, wrong dosage, dispensing frequency, and medication omissions. Possible causes were identified, e.g., the fax machines malfunction, legibility of physician writing, communication between nurses and pharmacological staff, environment, interruptions, and noise.

After initiating changes to reduce the potential of errors from occurring, the results indicated the total errors in those four categories were reduced from 213 to 96 (Esimai, 2005). Anecdotal side effects of the changes included a projected cost saving of $1.32 million per year, increased patient satisfaction, and improved employee morale/job satisfaction (Esimai, 2005).

In another study by Lepper et al. (2003), the pharmacy staff at a large cancer treatment center, Cancer Treatment centers of America at Midwestern Regional Medical Center (CTCA at MRMC), used CI techniques of 5S, process mapping, and a “just-in-time system” for supply stocking to reduce the internal medication error variance. The authors indicated an overall reduction in error variance was achieved; however, specific levels of reduction were not published. In addition to reduction in error variance, a reduction of 50 percent in the number of process steps in pharmacological processes associated with chemotherapy were reported, but no significance testing was performed on those reductions (Lepper et al., 2003). In summary, this study identified and reduced the variability of delivering medication to chemotherapy patients. Part of that reduction in variation may be due to the 50 percent reduction in steps associated with the dispensing of drugs to these patients. The next section details studies focused upon the errors and error prevention associated with unnecessary surgical procedures and the reduction of postoperative infections.

2.3.4.2 Postoperative infections

In American hospitals, health care associated infections account for an estimated 1.7 million infections yearly, of which 22 percent are surgical site infections (SSIs) (CDC, 2002). Most of these SSIs can be eliminated if postoperative antibiotics are given according to national guidelines (Le, et al., 2009). Sewickley Valley Hospital was part of a Six Sigma project of the Heritage Valley Health System (HVHS) in 2001. The HVHS included three hospitals, 49 physician offices, a surgery center, and 14 community satellite facilities. The HVHS objective was to prevent SSIs. Prior to the interventions, compliance in antibiotic administration within one hour of surgical incision was 19 percent, and the compliance for discontinuing antibiotics within 24 hours of surgery was three percent. Several CI practices were employed, including Process Failure Mode and Effects Analysis (PFMEA), process mapping, cause and effect diagrams, and SPC charts, to aid in understanding the problems in an objective manner and to monitor performance after new procedures were employed. Compliance of administering antibiotic within one hour of incision increased to 100 percent, which was an increase of 81 percent over initial data. In addition, compliance of discontinuance of antibiotics within 24 hours after surgery increased to 79 percent, an increase of 76 percent over the initial data (Beaver, 2004).

Bloodstream infections represent the eighth leading cause of death in the United States (CDC, 2001). As many as 28,000 patients die each year due to catheter-related bloodstream infections (John Hopkins Hospital, 2004). Stahl (2002) reported that Yale-New Haven Hospital staff, using Six Sigma tools, identified the problem of acquired bloodstream infections as important to reduce in intensive care units (ICUs). A cross-functional team, which included leadership from ICU and Infectious Disease Control, was assembled to define the problem and identify possible causes. The team used Ishikawa diagramming, which divides a problem into specific categories and allows for the identification of processes within each category as possible causes of failure. The types of catheters used and the processes for insertion and removal were determined to be the most likely causes of infection. New procedures and a video demonstrating the correct practices were produced. In addition, a standard kit of equipment needed to insert and remove a catheter was developed and implemented. Thus, a noticeable reduction was observed in hospital-acquired infections after introduction of these practices in the ICU (Stahl, 2002). A complete delineation of the exact reductions was not included in the published results of this study.

2.3.4.3 Unnecessary operations

The rate for induced labor has doubled from 1989 to 2001 and has increased from 10 percent to 20 percent of all births (Martin, et al., 2002). First-time mothers are twice as likely to have the induction result in a cesarean section if induced at Week 41. The estimated associated cost in 1997 for these births was between $29M to $39M annually (Kaufman et al., 1997). Procedures that result in a patient undergoing an unnecessary operation expose that patient to additional opportunities for SSIs and the associated problems with the delivery of antibiotics. In addition, induced births have been associated with uterine hyper stimulation, which can result in fetal distress and require a cesarean section (Goer, 1999).

In a study of a 93-bed obstetrics facility at British Columbia's Women's Hospital and Health Centre, the induction rates, prior to any changes in procedures, were reported to be between 23 percent and 25 percent, which is unusually high in their low-risk patient population (Harris, et al., 2000). A cross-functional team of nurses, physicians, and health records personnel were assembled to define the problem and put corrective actions in place to reduce the rate of inductions. The team used a model based upon the Shewhart Diagram (Plan, Do, Check, Act,). Changes instituted at this hospital included a peer review of all requests for inductions, the establishment of clear criteria for induction, and improving the way inductions were recorded in the database. The result indicated a reduction of 43 percent in post-term pregnancy, a 53 percent reduction in premature rupture of membranes and preeclampsia, a 51 percent reduction in suspected fetal jeopardy, and a 57 percent reduction in maternal disease (Harris, 2000).

2.3.5 Patient satisfaction

In the hospital industry, patient satisfaction is immensely important (Krizner, 2007). Designing hospitals to provide a warm and inviting atmosphere is one approach to attract and retain patient loyalty that is being used more frequently. In 2000, the Memorial Sloan-Kettering Hospital opened a 190,000 square foot outpatient pavilion with waterfalls and sculptured gardens, focusing on body and mind as well as technologically progressive methods of caring for patients (Klucas, 2000).

Hospitals have begun to bring uniformity to patient satisfaction measurement as a result of the hospital report card that was initiated by the Department of Health and Human Services; however, a national benchmark for the collection and analysis of patient satisfaction data is still nonexistent.

In addition to the push by the Department of Health and Human Services, there is a belief among hospital administrators that satisfied patients will be more likely to return to the same facility for additional treatments in the future (Bolus & Pitts, 1999; Guadagnino, 2003; White, 1999). It is thought that dissatisfied patients go to other facilities, which reduces the opportunity of gaining additional revenue from loyal returning patients. In addition, it is also believed that patient feelings of loyalty could be transferred to the patients' friends and family, increasing the likelihood of additional revenue resulting from elective procedures (Bolus & Pitts, 1999; Guadagnino, 2003; White, 1999). However, there is a lack of empirical data to support these claims.

Patient questionnaires are the most often used method for gathering patient satisfaction data. Most of this information is gathered through mailed responses from recently discharged patients. The EDs of many hospitals are actively using patient satisfaction data to identify opportunities to improve their services (Trout et al., 2000).

A study at the University of Wisconsin, LaCrosse Student Health Center, used CI tools to identify and improve the patient satisfaction rating of their clinic. The data came from survey information collected from 500 students who attended the clinic. This information established a pretreatment baseline for patient satisfaction. These initial responses indicated an overall patient satisfaction rating of 59 percent. The staff employed a brainstorming session, which resulted in the following suggestions for change: (a) alter the scheduling of appointments and (b) improve the atmosphere in the waiting area. After implementing the changes, patient satisfaction increased to 73 percent (Eilers, 2004). It should be noted that the same students were not surveyed after the implementation. Therefore, different students might have rated the clinic higher irrespective of any implementation efforts.

Hyrkas and Lehti (2003) studied the use of CI to monitor staff interactions with patients over a two-year period at a large 1,111-bed hospital in Tempere, Finland. Participation was restricted to several wards within this hospital. The total number of patients surveyed during this two-year period was 2,005. Data were gathered from four areas: (a) satisfaction with courtesy to patients, (b) adequacy of information, (c) consideration for patients' opinions and wishes, and (d) staff competence. Survey items used a Likert scale from 4 to 10, with 4 representing poor and 10 equaling excellent. The patients completed the questionnaire at the end of their stay, prior to leaving the facility. The scores for these areas were then converted into control charts. During the two-year period, the data was charted and the staff analyzed the results regularly.

One outcome of this improvement effort was that variability in nurse-patient interactions was reduced when the charts were used, indicating that a more consistent approach appeared to have been adopted by the nurses. In addition, patient satisfaction scores continued to increase. Thus, charting and monitoring their own behavior appeared to have had a positive effect on patient/nurse interactions (Hyrkas & Lehti, 2003).

2.3.6 Employee satisfaction

Employee satisfaction has been positively associated with employees' work performance and longevity of employment with their current employer (Locke & Latham, 1990). Conversely, dissatisfaction can be associated with the premature departure of employees from their current employer (Seybolt, 1983). This is evident in many fields, but none more so than in the current crisis facing the health care industry. The health care industry in the U.S. is facing shortages of both nurses and physicians (Croasdale, 2005; Rosseter, 2008). One prediction foretells that the current supply of registered nurses graduating from colleges and universities in the U.S. cannot keep up with the demand for approximately 200,000 physicians and 340,000 nurses by 2020. Fifty-five percent of 1,000 nurses surveyed by nursing management, on-line journal of nursing professionals, reported their intentions to retire between 2011 and 2020 (Rosseter, 2008). Not only is it important to increase the number of nurses and physicians that are graduating, but those already in the profession must be retained. The CI activities, particularly TQM, have long been thought to be associated with improving employee satisfaction, loyalty, and longevity (Gvazdinskas & Maffetone, 1995; Kivimaki et al., 1997).

Patient care and satisfaction have been associated with nurse satisfaction. Another factor affecting nurse satisfaction is that of nurse-patient ratios (Aiken et al., 2002; Needleman et al., 2002). Each additional patient per nurse resulted in a seven percent increase in the likelihood of the patient dying within 30 days after admission, a seven percent increase in failure to rescue, a 23 percent increase in burnout, and a 15 percent increase in job dissatisfaction (Aiken et al., 2002). These dissatisfiers for nurses also have an adverse effect on patient satisfaction, and subsequently the patient's family and friends, leading ultimately to possible lost revenue.

The administration of Rush Medical Laboratories decided to focus on employee satisfaction. Rush Medical Laboratories is part of Rush University Medical Center, a large hospital with over 600 beds. Through employee training at all levels, along with the use of team building and self-directed work teams, Rush Medical Laboratories was able to increase workflow, provide employees with a environment conducive to express ideas or offer suggestions, and help employees develop an increased appreciation of each other's strengths. In addition, employees increased productivity, developed cost savings measures, and helped meet laboratory and institutional cost and operational goals (Gvazdinskas & Maffetone, 1995). Although none of the improvements were quantifiable, the overall impression was that through the use of TQM practices, the administration at Rush Medical Laboratories was able to improve employee satisfaction.

Sommer and Merritt (1994) studied a large Midwestern rehabilitation hospital that used TQM training to improve employee attitudes towards work, which have been shown to be a predictor of job satisfaction (Hackman & Oldham, 1975). Prior to implementation of the TQM training, the level of unexcused absences and employee turnover was measured and retained for later comparison. Post-TQM training indicated a decrease in unexcused absences by 37 percent over the pre-training levels. In addition, a 10 percent reduction in employee turnover was observed over the pre-training levels (Sommers & Merritt, 1994).

Another study of interest regarding employee satisfaction was conducted by Kivimaki et al. (1997). The authors examined how the implementation of TQM affected the well-being and work-related attitudes of health care personnel in hospital wards in three surgical departments of a large hospital in Finland. Only one of the three departments within this hospital applied TQM, the others did not. A questionnaire with 47 questions was sent out to the TQM and non-TQM clinics. The results indicated that the level of well-being and work-related perceptions were significantly higher for the TQM wards than those wards that did not implement TQM (Kivimaki et al., 1997).

Based on the literature, there is tentative support for the historical claims that TQM has a positive effect on employee satisfaction; however, these studies were conducted in large hospitals. Further research investigating medium and small-sized hospitals is needed to determine if similar relationships exist.

2.4 Summary

The literature review illustrated the application of CI practices to effect a positive change in one or more dependent variables. In many of the studies summarized, the quantitative analysis to validate results was not provided within the study. In addition, most of the studies reviewed used a few practices to improve a single variable.

Lastly, hospital size was not conclusively found to predict success or failure of CI projects. The role of hospital size is unclear. Three opinions within the literature on manufacturing organizational size were found. The first opinion is that smaller organizations were hypothesized to be more agile, more in-touch with the problems, better able to work cross-functionally, and rely less on internal divisions (Guisinger & Gorashi, 2004; Lawrence and Hottenstein, 1995; Ramalingram, 1996; White et al., 1999). The problems attributed to the larger organizations were that employees tend to function in departmental silos with centralized organizational structures and were slower or less agile in decision making.

The second opinion voiced in the literature is diametrically opposed to the finding that smaller is better. Some researchers have found that the larger the institution, the better able it was to implement a CI project, because of the additional human and financial resources (Shah and Ward, 2003; Ismail et al., 1998; Poole, 1998). These studies have identified that functional organizations play different roles, and a cross-functional approach draws from each of the areas of expertise. The final view is that size is irrelevant. Other factors, such as leadership, size of the project, number of employees, and number of practices were found to have a larger impact on change within an organization (Rodwell & Shadur, 1997; Sadikoglu, 2004; Taylor & Wright, 2003).

There are many questions left unanswered after reviewing the body of literature on the use of CI activities in health care. Previous research has not fully investigated the adverse effects that one or more variables might produce when interactions occur, neither have the improvement effects of combining practices been investigated. This study analyzed how a combination of practices is related to improvement in a broad range of outcomes. In addition, this study examined the effects of the number of trained employees, the number of departments involved in CI projects, and the number of CI tools used on a set of outcomes. Finally, the size of the hospital was also evaluated, to determine if there is a difference between small, medium and/or large hospitals. The results of this study provide hospital administrators with important insights into practices that can be used to produce desirable results in their organization.

3 Methodology

3.1 Hospital Demographics and Census Usage

In order to understand the relationships between the independent variables (employees trained in CI tools, departments involved in CI activities, the number of CI tools used in each activity, individual tool, and the focus of tool) to the dependent variables (lab wait times, costs, bed turn times, errors, customer satisfaction, and employee satisfaction), over 200 hospitals in Oregon, Washington, and Idaho were surveyed. Prior to describing the research methodology, a description of the demographic characteristics of hospitals is provided. The measures and methods used for this study are then described, concluding with the strategy used for summary analysis.

This research targeted 206 hospitals located within the Northwestern states of Oregon, Washington, and Idaho in the U.S. The categorization used to determine the three groupings of small, medium, and large was developed by the American Hospital Association (AHA) in a benchmarking survey of hospitals within the U.S. The categorization used for the AHA study was: hospitals with one to 99 beds were labeled as small, hospitals with 100 to 299 beds were labeled medium, and those with 300 or more beds were labeled large (AHA Benchmarking Survey, 2002).

3.1.1 Oregon

The Oregon Association of Hospitals provided the listing of the current number of 60 hospitals for the state of Oregon, which was used for this study. The breakdown for the hospitals within the state of Oregon was as follows: 29 Acute

Care Hospitals, 19 Type B Rural, and 12 Type A Rural (Office for Oregon Health Policy and Research, 2004). Type A Rural hospitals were defined as small and remote. Type A Rural hospitals typically have 50 beds or less, and are located more than 30 miles away from another acute inpatient facility. Type B Rural hospitals were defined almost the same as Type A Rural hospitals. The only difference was that Type B Rural hospitals were located less than 30 miles from the next acute inpatient care facility. An acute inpatient care facility is a facility that has emergency services available (e.g., Emergency Room or ED). These facilities are usually restricted to larger hospitals found in larger metropolitan communities (see Table 3). To summarize, using the AHA guidelines (2008) for small, medium, and large hospitals, Oregon has 40 small, 13 medium, and seven large facilities, for a total of 60 hospitals.

Table 3: Summary of Hospitals for Oregon by Size

	Small (1-99 beds)	Medium (100-299 beds)	Large (300+ beds)	Total
Total	40	13	7	60

3.1.2 Washington

The information regarding Washington's hospital distribution by size came from the AHA (2008). There were 98 community hospitals, included in the study. As shown in Table 4, by using the AHA survey data, Washington's 98 Community Hospitals are divided into 58 small, 29 medium, and 11 large hospitals (Santere & Pepper, 2000).

Table 4: Summary of Hospitals for Washington by Size

Small (0-99 beds)	Medium (100-299 beds)	Large (300 + beds)	Total
58	29	11	98

3.1.3 Idaho

The information regarding Idaho's hospital distribution by size came from the AHA (2008). There were 48 community hospitals, divided into 38 small, seven medium, and three large (see Table 5).

Table 5: Summary of Hospitals for Idaho by Size

Small (0-99 beds)	Medium (100-299 beds)	Large (300 + beds)	Total
38	7	3	48

3.1.4 Census

A census is defined as the collection of information about all units in a population (Patterson, 2000). One advantage of using a sample over a census is the difficulty in obtaining information about all members in a population; other reasons are cost and logistics. It may be too expensive to contact everyone in a population or logistically impossible to test everyone (Drew et al., 1996). However, in this study, all of the participants were known and the cost of e-mailing contacts along with the website for the survey was minimal. Therefore, choosing a census over sampling was a viable option, and ultimately selected as the approach due to the limited number of hospitals.

The rate of return of surveys is dependent upon the relationship established by the researcher collecting administering the survey. It is common to obtain a rate of return of 60 percent or less of completed surveys (Drew et al., 1995; Ugboro &

Obeng, 2000). An 80 percent return rate is uncommon but not impossible, but typically requires multiple contacts and is dependent upon the design of the instrument, and the ease of responding (Dillman et al., 2009). Details used to contact recipients and survey design details are discussed later in this chapter.

3.2 Variables

This research is focused on the role of, number of full time employees trained in CI practices, number of departments involved in CI projects, the total number of tools used, the specific tool used, and the focus of tools i.e. effectiveness or efficiency, and how these independent variables effect the hospital performance as measured by a balanced scorecard of metrics, room turn time, patient cost per day, lab wait times, error reduction, patient satisfaction, and employee satisfaction. This section describes the independent and dependent variables chosen for study in this research.

3.2.1 Number of employees trained [independent variable] [H1]

Previous researchers have recognized training as important to the successful implementation of any CI activity. This principle was established by early leaders in the field of quality (Deming, 1982; Mizuno, 1990; Shingo, 1985). The more employees that were trained in CI tools, the more opportunities an organization would have to initiate CI activities. Employees trained in CI who are involved in CI activities are believed to produce greater improvement over non-CI trained employees (Wright & Taylor, 2003)

For this study, employee training was defined as any education related to CI activities and CI tools that were acquired either by enrollment in training internally, i.e. within the organization, or externally. Training was defined to be limited to individual, group settings, or online courses or certification. On-the-job training (OJT) was also considered training for this study. The number of total employees trained in CI tools was based on the total number of full time employees.

3.2.2 Number of departments involved in CI activities [independent variable] [H2]

The number of departments involved in CI activities was thought to be significantly related to the performance of the hospital in: operational costs (Ramalingam, 1996), turn times of regular rooms (Poole, 1998), customer satisfaction and error reduction (Carmman et al., 1996), and patient wait times for lab results (Lawence & Hottenstein, 1995).

The choice for this study was to use a number of departments within an organization involved with CI activities. As discussed above, the number of employees, physical number of beds served, and departments varied within each institution. This information was gathered to understand any patterns of responses which may have an influence on hospital CI activities and performance.

3.2.3 Tool variety as measured by the number of tools used in CI projects chosen from the list of CI tools provided [independent variable] [H3]

The number of tools used in CI activities was positively associated with improved gains in various dependent variables. Cua et al. (2001) proposed that the synergistic efforts of TQM, Just In Time (JIT), and Total Preventative Maintenance

(TPM) in a manufacturing environment would lead to improved results over the use of each set of tools individually.

In a study examining the quality management practices in Ireland, Ismail, Baradie and Hashmi (1998) found that those factories that used more CI practices had higher total mean scores when measured against the Malcolm Baldrige 1997 categories. The total percent of tools used was tabulated for each institution. The tools were presented in a separate section of the survey. Tool usage indicated the breadth of knowledge and training for organizations that engaged in CI activities.

In addition, Ismail, Baradie, and Hashmi (1998) used the Malcolm Baldrige 1997 criteria for scoring each of the facilities. Criteria focused upon customer satisfaction and employee satisfaction, and the results indicated that the more CI practices employed in CI activities, the higher the satisfaction for both customers and employees.

Determining the number of tools used for this study was necessary for examining the hypotheses. Thus, it was important to establish a strategy for accurately representing the institution's usage at the hospital level. For the purposes of this study, a tool may be used by a hospital repeatedly, but was only counted once in calculating the total tool usage.

3.2.4 Tool variety as measured by the type of tools used in CI projects chosen from the list of CI tools provided [independent variable] [H4 & H5]

Cua et al. (2001) found that higher levels of manufacturing performance could be expected when the different practices and basic techniques of TQM, JIT, and TPM were implemented together. Further, they were able to show that jointly these combined practices or techniques were responsible for significant improvements, including cost reduction, conformance to quality, volume flexibility, and on-time delivery. These manufacturing metrics are closely related to hospital-based metrics. For example, error reduction could be equated to “conformance to quality,” while reduction of bed turn times could be an equivalent to “on-time delivery,” and reduction in lab wait times is similar to the manufacturing concept of “volume flexibility.” Lastly, reduction in costs translates directly from manufacturing to the health care field (Cua, et al.).

This dissertation investigated tool usage specifically, whether effectiveness tools were used more than efficiency tools. In addition, this study investigated what tools were associated with each dependent variable, identification of tool clusters, and whether all three groups of hospitals used these two groups of tools equally (Cua et al., 2001; Ismail et al., 1998).

3.2.5 The hospital size

The literature review did not produce conclusive results to indicate size as a determining factor in hospital performance. Therefore, it was proposed that post hoc analysis be conducted to investigate any differences that were noted in the response patterns between large, medium and small hospital groups. The next section defines the dependent variables used in this study. The dependent variables chosen represent a balanced scorecard of metrics that provide a comprehensive view of some of the major functions of a hospital.

3.2.6 Balanced scorecard of metrics [dependent variables]

The metrics chosen for this study were developed based upon a review of the literature. The Agency for Healthcare Research and Quality (AHRQ) (2000) developed a system for measuring performance. These metrics covered financial, operational, clinical, and employee-focused elements of the organization (AHRQ, 2005). The purpose of these metrics was to provide guidance and promote the consistency of metrics from hospital to hospital. These metrics represent a sample of the measures that were suggested by IOM (2001). The metrics chosen are commonly reported by hospitals.

The model for this study incorporated concepts from both Kaplan and Norton (1998) and the IOM study (2001). The components of Financial, learning/innovation, internal business, and customer satisfaction are from Kaplan and Norton, and corresponding IOM suggested metrics comprised the basis for the dependent variables of this study (see Table 6). The purpose of Table 6 is to establish justification for using the currently defined dependent variables in this study by presenting data from the IOM and from current review of literature. Thus Table 6 is a summary of that effort. In addition, Table 6 illustrates the support the regulatory and research communities have for the importance of a Balanced Scorecard of Metrics within the health care industry.

Table 6 has two sections; the first section contains information from AHRQ; the second section contains information derived from the review of literature. Across the top of the table are the dependent variables for this study. To facilitate the identification of each of the studies, a traceability number was assigned to each article. The numbers appear at the end of the title in the body of Table 6 and in the reference pages that follow Table 6 within this section. Each of the studies was within the health care industry, and each of the hospitals was involved in at least one CI effort.

Table 6: Mapping of the Groupings of a Balanced Scorecard to Current Research

	Balanced Score Card					
	Financial	Learning/Innovation		Internal Business		Customer
AHRQ System Metrics	costs	error reduction	employee satisfaction	bed turn times	lab wait times	Satifaction
JCAHO Core Measures		X				X
Cost per Discharge	X					
FTE per Adj Occupied Bed	X					
Mean Wait Time in ED for Hospital Bed				X	X	
Physician Productivity (Relative Value Units)						
Net Revenue	X					
Medication Errors		X				
Errors Related to Procedure/Treatment or Test		X				
Number of Cardiac Arrests		X				
Re-Admission Rates						
Total Travel Distance						
Patient Complaint Rate						X
Patient Satisfaction4						X
Discharge Process Time						
Risk Adjusted Mortality						
Nurse Turnover Rate			X			
Nurse Vacancy Rate			X			
Employee Turnover Rate			X			
Employee Vacancy Rates			X			
Employee Satisfaction			X			
Review of Literature						
Revolution in Hospital Management[1]	X	X	X	X	X	X
Manufacturings Prescription for Improving Healthcare[2]	X	X	X	X	X	X
Lab order to results 16 minutes[3]				X	X	
A case Example for Measuring Medication Errors[4]	X	X				
Achieving Real Results with Six Sigma[5]			X		X	X
Integrating Six Sigma and CQI for improving Patient Care[6]	X	X		X		X
New York hospital looks to Six Sigma for culture change[7]		X		X	X	
Six Sigma 100% compliance in 3 months[8]	X	X				
Cost Reduction in Cardiac Surgery[9]	X	X		X	X	
Improvement Report: Lean Thinking Applied to Pharmacy Processes[10]		X			X	
Six Sigma efforts paying dividends for CT hospital[11]	X	X	X		X	
Providers, Payers and IT Suppliers learn it pays to get Lean[12]	X				X	X
Kaizen: Innovation for Nurse Managersto Improve Productivity[13]	X		X			X
Turning the Tide on Medical Errors in Intensive Care Units{14]		X				
Six Sigma Approach to Maximizing Productivity in Cardiac Cath Lab[15]					X	
Decreasing Turnaround Time Between Surgery Cases[16]	X		X			X
How Can you Keep Average Wait less Than 1 Hour[17]				X	X	
Continuous Quality Improvement in Public Health in Ghana[18]	X	X	X		X	X
Keys for Successful Implementation of TQM in Hospitals[19]	X	X		X		X

Across the top of Table 6 are the six dependent variables for this study, which represent a balanced scorecard of metrics. The left side of the table represents the references for which the metrics were used. The table is further divided in two sections. The upper half represents the AHRQ metrics used in their analysis, while the lower half provides a review of health care literature that incorporated the dependent variables. For example, Revolution in Hospital Management [1] appears to focus upon all six dependent variables. Another example from the upper half of the table (AHRQ Systems Metrics) shows that the JCAHO core measurements are error reduction and customer satisfaction.

The list of references used to develop Table 6 is included in Table 7. Each entry within Table 7 has a reference number in the first column and the citation in the second column. For example, the citation "Revolution in Hospital Management" (Table 6 [1]) is located in Table 7 by finding [1] in the left column and reading the reference in the next column.

Table 7: References for Information from Table 6

No.	Reference
1	Griffith, J.R., Pattullo, A., White, K.R., (2005). The revolution in hospital management. *Journal Healthcare Management, 50*(3), 170-189.
2	James, C., (2005). Manufacturing's prescription for improving healthcare quality. *Hospital Topics: Research and Perspectives on Healthcare, 83*(1), 2-8.
3	Woitas, M., Willemsen, K., (2004). Lab order to results in 16 minutes? You heard right! *ED Management, 16*(8), 89-90.
4	Reeve, L., (2003). Integrating six sigma with total quality management: A case example for measuring medication errors. *Journal of Healthcare Management, 48,* 377-391.

5 Sherman, J., (2006). Achieving real results with Six Sigma. *Healthcare Executive, Jan/Feb*, 9-14.

6 Revere, L., Black, K., Huq, A., (2004). Integrating Six Sigma and CQI for improving patient care. *The TQM Magazine, 16*(2), 105-113.

7 Berman, M., (2003). New York hospitals looks to Six Sigma for culture change. *Performance Improvement Advisor, 7*(11), 141-152.

8 Beaver, R., (2004). Six Sigma success: 100% compliance in 3 months. *Healthcare Benchmarks and Quality Improvement, 11*(5), 52-55.

9 Hamilton, A., et al., (1994). Cost reduction in cardiac surgery. *Cardiovascular Medicine, 10*(7), 721-727.

10 Lepper, C., et al., (2003). *Improvement report: Lean thinking applied to pharmacy*. Retrieved September, 9, 2004, from www.ihi.org.

11 Stahl, R., (2002). Six Sigma effort paying dividends for CT hospital. *Data Strategies & Benchmarks, January*, 1-6.

12 Lazarus, I. R., Andell, J., (2006). Providers, payers and IT suppliers learn it pays to get "lean." *Managed Healthcare Executive, February*, 34-36.

13 Kerfoot, K., Rohe, D., (1989). KAIZEN: Innovation for Nurse Managers to Improve Productivity. *Nursing Economics*, *7*(4), 228-230.

14 Rogerson Jr., W. T., Tremethick, M. J., (2004). Turning the tide on medical errors in intensive care units. *Dimensions of Critical Nursing, 23*(4), 1-9.

15 LeBlanc, F., et al., (2004). A Six Sigma approach to maximizing productivity in the cardiac cath lab. *The Journal of Cardiovascular Management, 15*(2), 19-24.

16 Adams, R., etal., (2004). Decreasing turnaround time between general surgery cases. *Journal of Nursing Administration (JONA), 34*(3), 140-148.

17 McGrayne, J., (2004). How can you keep average wait less than 1 hour? VHA shares its strategies. *ED Management*, *16*(1), *37-39*.

18 Agyepon, I. A., (2001). Continuous quality improvement in public health in Ghana: CQI as a model for primary health care management and delivery. *Quality Management in Health Care, 9*(4), 1-10.

19 Carmen, J. M., et al., (1996). Keys for successful implementation of total quality management in hospitals. *Health Care Management Review, 21*(1), 48-60.

3.3 Survey Development and Data Collection

3.1 Tailored design

The difference between a tailored design and other designs derives from the use of multiple motivational features along with mutually supportive devices to stimulate greater participation and improve accuracy of survey responses. The theoretical underpinnings of tailored design are founded in human behavior, suggesting that individuals are more likely to respond if they perceive a direct or indirect benefit from responding (Dillman et al., 2009).

When additional motivation is not provided, or the individuals do not perceive benefit, then four common types of errors can occur: coverage, sampling, non-response and measurement. Coverage error occurs when not all of the members of a population have a chance of inclusion within the study. Sampling error occurs when a non-random sample has been developed and implemented. Non-response error occurs when only motivated individuals respond, and they may not be a true representation of the population or sample. Finally, measurement error arises from poorly written or vague questions, allowing for multiple interpretations by the participant to the question and of the responses by the experimenter (Dillman et al., 2009).

This study attempted to reduce the four errors with the inclusion of all non-state or highly specialized hospitals within Oregon, Washington, and Idaho. Sampling error, as defined above, was removed by using a census. All hospitals were included in the study, to eliminate selection bias. Non-response error was more difficult to control for, but was managed through several mechanisms including multiple personal e-mail contacts and establishing a single point contact in each hospital, to reduce problems with e-mails being deleted prematurely. In addition, a website was established, and an active link was provided to each participant. Anonymity was engendered using individualized personal identification numbers. When necessary, a electronic copy of the survey was sent by e-mail to participants upon request, and the return of the completed survey was also accomplished through e-mail. Section IV of the survey was included so that participants could discuss what they felt was important, and what they felt was necessary for CI to occur. Measurement error is always a problem, so this study developed four sections with instructions at the beginning of each section. Definitions were also provided for terms used in the survey to aid in interpretation.

The explanation above is a summary of the methods that were used to produce a tailored design. The next section briefly touches upon what was mentioned, and then expands upon those ideas and the ways in which they were incorporated into the development of the survey, the logistics of implementation, and the contact information.

3.2 Survey development and Content

The survey was divided into four sections. Four sections were developed to provide consistency and continuity of the questions and to incorporate gestalt grouping principles (Dillman et al., 2009). For each section, the questions were developed to be direct answers, with no option of vague or misleading verbiage. For example, "What is the percent of Medicare and Medicaid Patients in 2006_____, 2007_____?" These types of questions call for direct and simple answers. The selection of four sections provided for content consistency and visual clarity, with only a few questions per page and per section. Only information that was necessary to the study was requested. Nothing was asked that would require a participant to disclose privileged or confidential information. These guiding principles were established to protect the participant and to increase confidence in the integrity of their responses (Dillman et al., 2009).

Section I asked simple background questions (e.g., how many beds does the hospital have). The idea was to begin with simple questions and then to move to more difficult questions as the survey progressed through each section, with the final section providing respondents the opportunity to express feelings and promote ownership (Dillman et al., 2009). These were also important identifiers used to categorize the hospital and provide needed information for the dependent variables.

Section II was more difficult than Section 1, by plan, to shape the completion behavior of participants (Bandura, 1969; Dillman et al., 2009). Having the participant answer easier questions can help establish a positive attitude towards the survey and ultimately improve the likelihood that a participant will complete all of the sections. Building upon success can possibly provide the participant with a feeling of accomplishment. In addition, this section was the source of information required for the dependent variables. The questions in this section had two parts, with the first part a simple yes/no answer, and the second part a follow-up to the first part. Continuity was important throughout the survey, but especially in this section because of the relatedness of the questions. Any separation of the two parts would have induced a discontinuous process for the participant, and thus, possibly reduced both the response accuracy and completion rate (Dillman et al., 2009). For example, "Was the hospital engaged in CI (e.g., Six Sigma, Lean, TQM, or other CI process to decrease patient cost YES NO?" "What were the patient costs for: 2006____, 2007___?"

Section III was heavily dependent upon a common knowledge and definition of terms related to CI. A list of definitions was provided to each participant electronically to reduce interpretation errors, which could effect the integrity and consistency of the responses (Dillman et al., 2009). The purpose of this section was to establish what tools were being used by these participants and if efficiency or effectiveness tools were used more often. In addition, an understanding of which tools were used the most and which tools were being used the least across the participants was gained from this section. This was the longest section, with 34 yes / no answers (e.g., "Cycle Time Analysis 2006 yes/no, 2007 yes/no"). The development of these terms was the result of a lengthy review of previous studies. Based on this review, 33 different tools were selected for inclusion in the survey (one tool was inadvertently included twice). The standardized definitions used in this study are presented in the next section. The survey items in Section III were developed from an extensive literature review, the details of which are summarized in Table 8 and Table 9.

Table 8: Mapping of the Continuous Improvement Tools to Specific Studies

		Research Articles																																									
	Continuous Improvement Practices	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	Problem Correction																																										
1	5S											1										1							1														
2	Pok-A-Yoke																												1														
3	Delivery Performance Improvement																												1														
4	New Process Equipment/Technology	1	1									1																	1														
5	Quick Change Over Technology			1			1			1						1													1								1				1		
	Inventory																																										
6	JIT		1		1			1									1							1						1		1				1	1			1	1		
7	Cycle Time Analysis		1	1	1	1	1						1	1		1						1					1		1					1									
8	Point of Use Stocking																	1											1														
9	Kanban/Pull System	1					1	1							1			1	1										1								1				1		
	System Analysis																																										
10	Process Capability Analysis																																								1	1	1
11	Value Added Analysis																																								1		1
12	SIPOC																																								1	1	
13	Value Stream Mapping																																								1	1	
14	Process Mapping																																								1	1	
15	Lead Times Analysis							1			1		1		1	1					1					1											1				1		
16	Travel Time											1						1								1			1														
17	Process Variation Analysis												1	1		1																											
	Carting																																										
18	Statistical Process Control																															1				1							1
19	Pareto Analysis									1	1									1				1					1														1
20	Histogrms/Bar Charts																																								1		
21	Frequency Polygones/Lin Charts																																								1		
	Error Analysis																																										
22	Cause & Effect Diagrams/Ishikawa/Fishbone																																								1	1	1
23	Decision Tree																																								1	1	
24	Six Sigma						1		1				1		1	1						1				1															1	1	
25	FMEA								1		1																														1	1	
26	5 Why's																																								1		
	External Analysis																																										
27	BenchMarking			1			1						1														1																
28	Customer Requirement Analysis																												1	1			1										1
29	Affinity Diagrams																																										
	Employee Centered																																										
30	Self Directed Workteams		1		1		1		1	1			1	1	1						1	1						1	1				1				1				1		1
31	Cross Functional Teams				1		1						1		1			1			1	1	1						1														1
32	Quality Circles						1																														1				1		1
33	Work Cells			1	1					1												1			1	1		1	1														1
34	Pay for Performance																												1			1				1							1

Across the top of Table 8 are numbers that refer to a study where a particular CI practice was found. Each of those numbers across the top of Table 8 has a corresponding number on the left side of the reference listed below Table 9. The information on the left side of Table 8 represents the practices of interest to this study. Going to the row and then moving across the columns to determine which research included that particular CI practice. For example, the practice of 5s was found in studies 11, 21, and 28.

Table 9: References Used in Table 8

No.	References
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Section IV was used to gather the participants' opinions and views on CI activities and to identify activities that were not represented in the survey. It provided important information relating to participant's ideas and feeling, provided stimulus for possible future research, and encouraged ownership of the survey answers, which was hypothesized to increase rate of return for completed surveys (Dillman et al., 2009). The respondents to Section IV of the survey were also used to provide the pool of participants from which nine hospital representatives were selected to participate in a follow-up telephone interview.

3.3.3 Survey items definitions

Definitions for terms used on the survey were available on the survey through a pop-up window. If the participant was unsure of a term, the instructions were to place the curser over the term and a pop-up window would automatically appear containing the definition. This additional tool was designed to reduce errors resulting from incorrect or inaccurate definitions. The definitions available to each participant in pop-up windows are defined below as they appeared in the survey.

Work Cell: The act of locating representatives from one or more areas, including, but not limited to: pharmacy, lab, housekeeping, transportation, admitting, etc. to a common area to foster sharing of ideas and resources.

JIT (Just In Time): The act of delivery of only enough materials, and only before they are needed.

Cycle Time Analysis: The act of analyzing the duration of time required to perform a task or tasks (e.g., LOS [Length of stay], lab work, drawing blood, etc., for purposes of reducing time and eliminating non-value-added steps or activities).

Point of Use Stocking: The act of locating materials adjacent to their consumption (e.g., medication located in secure area on floor).

Kanban/Pull System: The act of delivering a person or product to the next location or station, only after a signal to transport has been given (e.g., waiting for the lab to call before delivering patient to lab, etc.).

Lead Time Analysis: The act of studying the time required to deliver a service or product for the purpose of reducing the time required to deliver that service or product (e.g., reducing the time to receive a prescription after order is entered).

SDWT (Self-Directed Work Teams): The act of forming a group of employees for the sole purpose of providing a service or product with minimal or no supervision (e.g., pharmacy staff forming team to govern their activities and make decisions for improvement(s)).

Value Added Analysis: The act of studying tasks to determine which of those tasks increase the worth of the product or the service to the customer. For example, the verification of the accuracy of the medication the patient is to receive prior to administering the medication to the patient

New Process and Equipment Technology: The act of incorporating new equipment and or processes with the desired goal of improving the current delivery of service, (e.g., new patient monitoring device that provides clearer viewing, easier operations and more patient information, or incorporating a process for admitting that reduces time to process a patient into the hospital).

Travel Time Analysis: The act of studying the duration of time required to transport people or products to the next location, for the sole purpose of decreasing the event (e.g., reducing the time required for transportation to arrive at the nurses' station after the signal has been sent).

Cross-functional teams: The act of bringing together a diverse representation of employees from different areas within the same corporation, hospital, or company, for a specific period of time for the sole purpose of resolving a product or process-related problem (e.g., pharmacy, nursing, physicians coming together to resolve legibility concerns in prescription ordering and filing processes).

Customer requirements analysis: the act of systematically reviewing each individual customer requirement with the intent of modifying or developing a process or procedure to meet the needs of the customer (e.g., review customer satisfaction responses to identify unsatisfied needs, and then develop or modify processes to meet those needs).

Failure Mode and Effect Analysis (FMEA): The act of systematic analysis of a failed product, process, or system, in order to understand the effects of the failure upon the product, process, or system and finally to determine how the failure occurred in order to prevent re-occurrence. For example, understanding the failure of the nurse to find the desired vein the first time and puncturing the patient five more times until successful).

Mistake Proofing (Poka-Yoke): The act of developing procedures and or processes with the sole of eliminating the possibility of human error (e.g., placing a mat with the silhouette of each instrument in the bottom of the tool tray to avoid missing tools, writing "REMOVE" on the patient limb that is to be removed).

Process Capability Analysis: The act of analyzing a process or system of processes to determine if the desired outcome is possible (e.g., analyzing the discharge process, and determining that a 90-minute discharge is not possible because of the travel and location of key individuals).

Quality Circles: The act of forming a group of employees from the same department for the sole purpose of decreasing defects or errors (e.g., employees from pharmacy changing the internal process so that fewer erroneous prescriptions leave the pharmacy).

SPC: The act of measuring products determining average maximum and minimum allowable variation and developing a recording medium to track future products variation to ensure that the variation does not go above the maximum or below the minimum allowable variation (e.g., monitoring the admitting process to ensure time to admit stays within the defined maximum and minimum time).

Process Variation Analysis: Analysis focused on decreasing the variability within a process, e.g. observing variation in cleanliness of rooms because the procedural steps are vaguely defined removing the vagaries and adding additional steps to increase sanitation.

5S: The act of organizing and standardizing of the workstation through the following activities:

1. Sort through all items and remove unneeded items.
2. Set in order remaining items, set limits, and create temporary location indicators.
3. Shine or clean everything and use cleaning as inspection.
4. Standardize the first three S's by implementing visual displays and controls.
5. Sustain the gains through self-discipline, training, communication and total employee involvement.

An example of 5S would be sorting through items in the nurses' station, removing unneeded items, finding locations for the remaining materials and labeling those sites for each item, cleaning the work spaces, floors, computers, etc., and always returning materials back to their assigned locations, and daily cleaning of the workstation.

Value Stream Mapping: the act of drawing the flow of materials and information required to bring a product or service to a customer, also known as Material and Information Flow Mapping.

Process Mapping: The act of drawing the flow of material and or services that represent the process. An example is a drawing showing the flow of:

1. The patient's movements to the lab.
2. The work done on the patient in the lab.
3. The time the patient waited before lab test and or after lab test.
4. The activities the lab does to process the test.
5. The transportation of patient back to the patient's room.
6. The transportation of the information from the lab to the recipients the information was intended.

Delivery Performance Improvement: The act of moving the product to the customer, such that the customer's satisfaction with the delivery act is increased.

Fishbone Diagram (AKA Ishikawa Diagram, Cause & Effect Diagram): The act of a team or a group identifying a problem as the effect, and then arranging the likely causes using the five categories of people, methods, materials, machines, and measurements. These categories are arranged above and below a horizontal line that is connected to the effect, thus showing a probable link. Each category is then discussed, and a possible reason is listed under each category with the results resembling a skeleton of a fish. For example, the effect is poor operating room turnaround time, so the causes could be:

1. Machine: Difficult to clean, or not available.
2. People: Nurse busy, housekeeping busy, surgeons late, materials, supplies not available, implants not available, measurements, poor time recording, inability to properly record elapse-time, not recording cleaning time.

SIPOC (Supplier Input Process Output Customers): The act of drawing a flow chart showing the relationship between the supplier inputs process outputs and the customer.

DMAIC: The act of

1. Defining the variable to be studied within the process
2. Measuring the variable studied
3. Analyzing the data measured
4. Improving the process
5. Controlling the improvement to the process

For example, if the problem defined is the need to reduce the time to discharge a patient, data is collected on the process steps along with the time duration to discharge a patient. It is analyzed that the data shows that filling out prescriptions by doctors takes a long time. The decision is made to have the doctor fill out the prescription the night before, and the doctors begin to fill out the prescriptions the night before, and then the discharge process continues to be measured to see if filling out the prescription the night before resulted in shorter discharge times.

Pareto Analysis: The act of reviewing items and ranking them to determine which items add up to a cumulative amount equal to 80 percent of the total items reviewed.

5 Whys': The act of questioning an interviewee by asking why after they produce an explanation to produce another answer more related to the first, and continuing this process for a total of 5 Whys' in order to determine an answer that appears to be the cause of the identified problem.

Affinity Diagram: The act of a group of employees recording the customer requirements (voice of the customer) onto a chart with logical categories under which each requirement falls.

Customer Surveys: The act of distributing a request for specific information from a customer in order to assess their thoughts, needs, and/or level of satisfaction.

Benchmarking: The act of systematically analyzing more than one system for the sole purpose of determining similarities and differences, with the intent of adopting practices and processes that reduce waste and increase desired outcomes (e.g., the ED from hospital A visiting the ED from hospital B with similar patient population, in order to observe different triage practices and processes to incorporate into hospital A).

Pay for performance: The act of reinforcing an employee with money for specific activities completed. For example, an employee receiving pay for having fewer mistakes this week than last week.

Frequency Polygon (Charting): The act of recording data that has been gathered onto paper with two referent axes, with Y running vertical and X running horizontal and intersecting the Y axis at one point, such that each data point has one and only one location on the paper, and that the points or locations follow some logical progression. For example, charting the temperature of patient "A" by hour would have the temperature in equal measurements noted along the "Y" axis, beginning with 95 degrees at the bottom and ending with 125 degrees at the top. The "X" axis would have each hour recorded, beginning with the first hour the temperature was taken, and then each other time it was taken. Thus, for the first time it was taken, patient "A" had a temperature of 100 degrees, so a dot would be placed at the intersection of 100 degrees on the "Y" axis and the first time period on the "X" axis.

Histograms (Charting): The act of recording data that has been gathered onto paper with two referent axes, with Y running vertical and X running horizontal and intersecting the Y axis at one point, such that each data point has one and only one location on the paper, and that the points or locations follow some logical progression.

A copy of the survey content is included as Appendix A. The next section describes the design of the logistics of the study including the multiple contacts, identification of the list of hospitals, point of contacts within each state, the form of the contacts, the distribution of the survey, the collection of the data, and the identification of the follow-up telephone interview to augment survey information.

3.3.4 Survey Logistics

The importance of contacting the participants was given high priority in this study. Fourteen steps were developed and followed for establishing contacts with the respondents for the Internet-based survey. E-mail was chosen because of the speed with which contacts can be made, because every participant has e-mail at their hospital (Dillman et al., 2009). To avoid e-mail filtering devices, a single point of contact for each hospital was identified. The contacts were obtained through a mailing list service which identified the administrator, CEO, or Quality director. The exact process is outlined next. The contacts were alerted through telephone calls prior to initial sending of e-mails. Below are the steps that were followed for contacting participants.

1. The addresses, phone numbers, and contact names for either the Director of Quality, or the CEO/Administrator for Oregon, Washington, and Idaho were purchased from an established company that has been involved in providing this information to researchers.

2. Each contact person was called, and their e-mail address was obtained from either them or their administrative assistant (first phone contact). An explanation of the survey was given, and their cooperation was requested. By making the initial contact, it was hoped that the person would become motivated and involved enough so that when the e-mail arrived with the website information, the response rate would be increased (Dillman et al., 2009).

3. The website was created professionally and established again by a company that has been doing websites for researchers for several years. The designers knew and understood how to format the survey to appeal to the target respondents.

4. A cover letter was created following Dillman's (2007) suggestions and format. Included in that letter was the reason for the study, who was conducting the study, the website information, and the researcher's e-mail addresses and phone numbers enable respondents to receive prompt answers to any questions. In addition, the rights and responsibilities and disclosure information that was submitted to Oregon State University's Internal Review Board (IRB) was sent to ensure that the participants understood their rights to participate or not. To induce interest to participate, it was made clear that they would only receive benchmarking information if they participated.

5. Each e-mail was personalized with the participant's name, address, title, and greeting, to avoid the appearance of mass mailing (Dillman et al., 2009). Again, the individual touch was to encourage bonding and increase participation.

6. The first e-mail was sent out to all participants from a database that was created for each state in a mail merge process using Microsoft Office Outlook.

7. Five days later, a second mailing was sent to everyone, reminding them of the first e-mail and providing the website and phone numbers for question. Again, participation was requested and the importance of participation was stressed (Dillman et al., 2009).

8. For all of the e-mails that were undeliverable or caught in spam filters, a mailing was sent out using the postal system, which contained the exact same information that was sent out originally in the e-mail. These letters were also personalized, and a follow-up mailing in five days was sent to these participants just like the e-mails.

9. Two weeks after the first e-mail and postal mailing, each participant was contacted by telephone (the second time) and a message was left for them asking for their participation and cooperation.

10. One week later, the third e-mail was sent out reminding them to participate and including all of the same information again. In addition, two offers were made: one to have them fill out and return a copy of the survey e-mailed to them, rather than use the website, and that each of them would

receive a small token of appreciation in the mail of a windshield scraper that was designed to fit inside their wallet and be used for emergencies.

11. Two days later, the postal mailing was sent out to all participating hospital contacts with the windshield scraper and another letter thanking them for participating, and a reminder of the deadline for closing. Included was the information for the website, and the offer to e-mail a copy of the survey in Microsoft Word or Microsoft Excel if they preferred that option.

12. Two weeks later the third phone contact, a voice-mail, was sent to each of the participants that had not sent in information, explaining the benefits, the importance of participation, and again the option to e-mail the survey and a reminder of the deadline.

13. Two weeks later, the fourth and last e-mail was sent to those who still had not participated, to remind them of the closing deadline.

14. The website was closed after two months.

Each Internet survey was assigned a number, and only the experimenter had access to the number keys to ensure anonymity. The survey was estimated to take no longer than 30 minutes. No signed consent forms were collected, which was acceptable due to the low risk to the participants for the informed consent agreement. The approved IRB protocol included examples of all of the communications, which are included Appendix C.

A thank-you letter and customized analysis of the results were sent to each hospital administrator that completed the survey. All respondents were kept anonymous in the summary data distributed to the hospitals. A list of all contacted institutions by state can be found in Appendix D.

3.3.5 Telephone Interview

The second part of this study was the telephone follow-up interview of participants. Seven questions were developed to extend and bolster the knowledge gained from the Internet survey. The participants for the study were chosen from the completed pool of Internet surveys. The participants were selected using a stratified random sampling procedure, to ensure consistent proportionality within each of the small, medium, and large hospital groups. The script and questions were printed along with the name of the contact, the hospital's name, and the contact's phone number, to be used as data recording sheets (see Appendix B). The telephone call time was 10 minutes in duration, in order to minimize the impact of this additional survey.

3.4 Analysis

The primary focus of this research was to develop a more complete understanding of the relationship between CI implementation practices and tool variety (number and focus) on hospital performance as measured by a balanced scorecard of metrics. Five research questions were developed. These questions form the basis for understanding the relationships and determine if there is a mix of the independent variables that produces the most benefit for an organization. The research questions and the means of analysis that was initiated to examine the significance of each relationship are described next.

3.4.1 Research questions

Research Question 1: Does the number of full-time employees trained in CI tools effect the hospital's performance? The hypotheses for Question 1 are the number of full-time employees trained in CI tools has an effect on:

H_{1a}: wait times for lab results.
H_{1b}: patient costs/day.
H_{1c}: times prepare a room.
H_{1d}: reduction in number of reportable errors.
$H_{1e.}$: overall rating for patient satisfaction for the hospital.
H_{1f}: overall rating for employee satisfaction for the hospital.

Research Question 2: Does the number of departments involved in CI projects effect the hospital's performance? The hypotheses for Question 2 are the number of departments engaged in CI Projects has an effect on:

H_{2a}: wait times for lab results.
H_{2b}: patient costs/day.
H_{2c}: times prepare a room.
H_{2d}: reduction in number of reportable errors.
H_{2e}: overall rating for patient satisfaction for the hospital.
H_{2f}: overall rating for employee satisfaction for the hospital.

Research Question 3: Does the total number of tools used in a CI project effect the hospital's performance? The hypotheses for Question 3 are tool variety, as measured by the total number of CI tools used in CI projects, has an effect on:

H_{3a} wait times for lab results.
H_{3b}: patient costs/day.
H_{3c}: times prepare a room.
H_{3d}: reduction in number of reportable errors.
H_{3e}: overall rating for patient satisfaction for the hospital.

H_{3f}: overall rating for employee satisfaction for the hospital.

Research Question 4: Do hospitals only use effectiveness or efficiency tools in CI projects? This lead to the hypothesis: Are hospitals equally likely to use effectiveness and efficiency tools in CI projects?

Research Question 5: Does the use of a particular CI tool in a CI project effect the hospital's performance? The hypotheses for Question 5 are the use of individual CI tools in CI projects has an effect on:

H_{5a} wait times for lab results.
H_{5b}: patient costs/day.
H_{5c}: times prepare a room.
H_{5d}: reduction in number of reportable errors.
H_{5e}: overall rating for patient satisfaction for the hospital.
H_{5f}: overall rating for employee satisfaction for the hospital.

3.4.2 Data Analysis

The statistical techniques used for this research included correlation, multiple regression, equality of central location analysis, and cluster analysis. For Research Questions 1-3, Kendal's tau b correlations were used to examine whether or not significant relationships existed between the dependent and the independent variables. Prior to regression analysis the data will be analyzed to determine if it is normally distributed, and/or ascertain what distribution the data represents. Where appropriate, regression analysis using a General Linear Model would be performed to determine if one or more of the independent variables (employees trained in CI, number of departments involved in CI, total number of CI tools used, and CI tool focus) were related to the six dependent variables used to assess hospital performance.

For Research Question 4, descriptive statistics were first used to characterize overall tool usage across the entire sample of hospitals. A Wilcoxon Sign Rank test was next used to determine whether or not the average number of effectiveness tools used differed from the average number of efficiency tools used by the hospitals participating in the study.

For Research Question 5, Kendal tau b correlations were used as a screening device to assess whether or not any significant relationships emerged between individual tool usage and the six dependent variables related to hospital performance. Kendal tau b correlations were used because the test is not dependent upon the condition that the data are normally distributed. Box plots were also created and studied to compare performance differences between hospitals that used a particular CI tool and those hospitals that did not use the same tool. In addition to the analyses conducted to address the defined research questions, follow-on analyses were completed, post hoc, to help provide additional insight into the results, after hypothesis testing was completed.

Follow-up telephone interviews were conducted with personnel from a subset of the hospitals who responded to the web survey to provide additional qualitative data to use in understanding the web survey results. The telephone interviews included seven questions. These questions were directed to participants from nine of the 17 responding hospitals. The nine hospitals chosen to participate in the phone interview were selected based upon a stratified random sample based upon hospital size. The interview responses were summarized and like responses were combined. Pie charts were created to provide an overall summary of the responses from the nine interviews.

Additional analyses were completed post hoc to examine the potential role of hospital size on the use and resulting impact of CI tools on hospital performance. Descriptive statistics were reviewed for both the independent and dependent variables for each group of hospitals by size. A Kruskal-Wallis test was used to determine whether or not hospital size had an effect on the observed results. The final analysis completed was hierarchical cluster analysis. Hierarchical cluster analysis was completed to determine whether CI tool usage patterns existed for any subsets of hospitals participating in this study. A Kruskal-Wallis test was used to determine whether or not significant difference in performance occurred between identified hospital clusters.

4 Results

This chapter summarizes the results of the analyses of both the survey and interview data. The analyses are organized into four sections. The first section provides a summary of various characteristics of the hospitals participating in the study. This section includes descriptive statistics for demographic factors, e.g. number of beds, number of admits, CI implementation practices, e.g. the number of employees involved in CI, and hospital performance, e.g. lab wait times. The second section provides a summary of the statistical analyses completed to test the five research hypotheses. The third section summarizes the results of the follow-up telephone interviews. The fourth section summarizes all post-hoc analyses completed to investigate the potential role of hospital size in the use of CI practices and to determine if clusters of hospitals could be defined based upon CI tool usage patterns.

To facilitate the presentation of results, abbreviations were developed for the various independent and dependant variables. These abbreviations are summarized in Table 10. In addition to the abbreviations used for the independent variables, acronyms were developed for each of the CI tools included in the study. Table 11 summarizes the acronym used for each CI tool included in the survey.

Table 10: Abbreviations for Survey Items

Abbreviation	Survey Item
# of Beds.	Number of licensed beds
# Pat. admttd.	Patients admitted
% CMS.	Percent of patients Medicare/Medicaid
% uninsured.	Percent of patients uninsured
# ER Pat.	Patients seen in emergency department
FTE Eng. CI.	Full-time employees engaged in CI
# of Depts.	Departments engaged in CI
FTE. Trnd. CI.	Full-time employees trained in CI
Red. Pat. Cost.	Staff engaged to reduce patient cost (yes or no)
Avg. Pat. Cost/Day.	Average patient cost per day
Red. Lab. Wait Times.	Staff engaged in reducing wait time for lab. results (yes or no)
Avg. Lab. Wait. Times.	Average wait time for lab results
Red. Rm. Time.	Staff engaged in reducing average time to clean a room (yes or no)
Avg. Rm. Time.	Average time to prepare a room
Red. Errors.	Staff engaged to reduce reportable errors (yes or no)
Errors.	Number of reportable errors
Imp. Pat. Sat.	Staff engaged in CI to improve patient satisfaction (yes or no)
Pat. Sat.	Overall rating of patient satisfaction for hospital
Imp. Emp. Sat.	Staff engaged in improving employee satisfaction (yes or no)
Emp. Sat.	Overall rating of employee satisfaction for hospital

Table 11: Acronyms used for CI Tools

Acronym	CI Tools
5s	Shine, sort, standardize, store, sustain
5Y'S	5 why's
AD	Affinity diagrams
B	Benchmarking
CS	Customer surveys
CFT	Cross functional teams
CTA	Cycle time analysis
CRA	Customer requirements analysis
DMAIC	Define, measure, analyze, improve, control
DPI	Delivery performance improvement
FBD	Fishbone diagrams
FMEA	Failure mode effect analysis
FPG	Frequency polygons
H	Histograms
JIT	Just in time
KBS	Kanban system
LTA	Lead time analysis
NPET	New processes equipment technology
PA	Pareto analysis
PCA	Process capability analysis
PFP	Pay for performance
PM	Process mapping
POUS	Point of use stocking
PVA	Process variation analysis
PY	Poka-yoke
QC	Quality circles
SDWT	Self-directed work teams
SIPOC	Supplier inputs process output customer
SPC	Statistical process control
TTA	Travel time analysis
VAA	Value-added analysis
VSM	Value stream mapping
WC	Work cells

4.1 Descriptive Summary of Survey Responses

4.1.1 Response Rate Summary

There were 206 large, medium, and small hospitals in Oregon, Washington, and Idaho invited to participate in the study. A total of 17 hospitals completed the entire survey or a substantial portion of the survey. The hospitals were categorized based upon the number of beds that each hospital was licensed for. Small hospitals were defined as those hospitals licensed for one to 99 beds, medium hospitals were defined as those licensed for 100-300 beds, and large hospitals were defined as those licensed for more than 300 beds. The largest number of surveys were returned from Oregon hospitals ($n_{Oregon} = 8$). Five surveys were returned from hospitals in Idaho, and four surveys were returned from hospitals in Washington. In terms of hospital size, only three large hospitals (all from Oregon) participated in the study. Five medium hospitals and nine small hospitals returned surveys. Response rates varied both by hospital size and by state. The overall response rates by size and by state are summarized in Table 12. Response rates for each state, by size, are summarized in Table 13.

Table 12: Overall Survey Response Rates by Hospital Size and by State

	Size		
	Small	Medium	Large
Number Responding (n)	9	5	3
Target Population (N)	136	49	21
Response Rate by size	7%	10%	14%
	State		
	OR	WA	ID
Number Responding (n)	8	4	5
Target Population (N)	60	98	48
Response Rate by state	13%	4%	10%

Table 13: Response Rates by State

	Small	Medium	Large
Oregon			
Number Responding (n)	2	3	3
Target Population (N)	40	13	7
Response Rate	5%	23%	43%
Washington			
Number Responding (n)	3	1	0
Target Population (N)	58	29	11
Response Rate	5%	3%	0%
Idaho			
Number Responding (n)	4	1	0
Target Population (N)	38	7	3
Response Rate	11%	14%	0%

4.1.2 Descriptive Statistics for all Respondents

Each hospital was requested to provide data on implementation practices, tool usage, and performance for two years (2006 and 2007). In reviewing the responses provided, many hospitals did not provide complete data for both years. However, relatively complete data sets were provided for the most recent year (2007). Therefore, it was decided to use only data from 2007 in all follow-on analysis.

Basic descriptive statistics were calculated based on 2007 data. Since not all items were completed by every hospital, the number of responses used to calculate summary statistics varies for survey items. In addition, one of the small hospitals responding to the survey completed only four of the requested items making it infeasible to include this hospital in many of the analyses. As a result, all subsequent analyses were done with the remaining 16 responding hospitals. Average values, standard deviations, and the number of hospitals responding to each survey item are summarized in Table 14. The items have been grouped based on the research model defined for the study.

The first set of survey items summarized are those items describing general characteristics of each hospital, i.e. number of licensed beds, annual number of patients admitted, percent of Medicare and Medicaid patients, percent of uninsured patients, and the annual number of patients seen in the emergency department.

The second set of items summarized is the percentage of responding hospitals who indicated that they were engaged in CI activities to improve performance related to lab wait times, costs, room turn times, error reduction, patient satisfaction, and employee satisfaction. A total of 16 hospitals responded to five of these six survey items. This summarized information provides a high level view of what performance elements were being targeted through the application of CI tools at the hospitals participating in this study.

The third set of items summarized are the independent variables related to implementation practices, i.e. number of employees trained in CI, the number of departments involved in CI, and the number of CI tools used. The acronym TTU (Total Tools Used) was used for the calculated measure of tool usage for each hospital. To calculate TTU, each tool was given a value of either 0 (not used) or 1 (tool used) for each hospital. A sum of these values was then calculated. If no tools were used the TTU value would be 0. If every tool was being used by a hospital, the TTU value would be 34. Total Tool Usage was further defined by calculating TTU efficiency and TTU effectiveness, i.e. total effectiveness tools used and total efficiency tools used.

The fourth set of items summarized is the dependent variables included in the study, i.e. lab wait times, patient costs/days, room turn time, errors, patient satisfaction, and employee satisfaction. Costs are summarized using US dollars, lab wait times and room turn times are summarized in minutes, and satisfaction scores were reported using a 5-point Likert scale. In this section of the survey, respondents were asked to provide actual performance data. This section of the survey had the lowest item response rate. Only five hospitals, for example, provided performance data related to errors.

Table 15 summarizes the analyses of the data, grouped by hospital size. This analysis enables a direct comparison between the responding hospitals based on size. For example, the mean for beds in large, medium and small hospitals were 623, 210, and 36 respectively, with yearly admittance rates of 9,586 for large hospitals, 9,139 for medium hospitals, and 730 for small hospitals. The difference between the admittance rates for medium and large hospitals was not as great as the difference between small and medium hospitals or the difference between small and large hospitals. Medium-size hospitals had slightly more uninsured patients than large hospitals (37% versus 34%). Small hospitals had the lowest percentage of uninsured patients at 29 percent. These data suggest a greater similarity between medium and large hospitals and appear to set small hospitals apart.

The ratios of full time employees trained in CI to available beds highlights a significant difference between small hospitals and the medium and large hospitals participating in the study. This ratio is 0.90 for large hospitals, 0.12 for medium hospitals, and 1.84 for small hospitals. Small hospitals participating in this study reported almost two times as many full time employees trained in CI per bed over the large hospitals and almost ten times as many employees trained in CI per bed than medium hospitals responding to the study.

Table 14: Descriptive Statistics for Demographic Factors, Involvement Responses, Independent Variables, and Dependent Variables

Variable	Mean	Std Dev	n
Demographics			
# of Beds.	200	231	16
# Pat. Admttd.	5,018	7,339	16
%. CMS.	61	17	15
%. Uninsured.	11	17	11
# ER. Pat.	18,661	16,439	13
Involvement responses			
Red. Lab. Wait Time.	25%		16
Red. Pat. Cost.	33%		15
Red. Rm. Time.	19%		16
Red. Errors.	44%		16
Imp. Emp. Sat.	50%		16
Imp. Pat. Sat.	63%		16
Independent variables			
FTE Trnd. CI.	84	145	14
# of Depts.	11	10	12
TTU	13	8.5	32
TTU Efficiency	5	4.3	16
TTU Effectiveness	8	4.8	16
Dependent variables			
Avg. Lab. Wait. Times.	22*	18*	9*
Avg. Pat. Cost/Day.	$2,485	$1,968	10
Avg. Rm.	43*	28*	6
Errors.	2	2	5
Pat. Sat.	1.8**	0.7**	14
Emp. Sat.	1.9**	0.5**	13

*In minutes
**Based on a rating scale of 1-5 with 1 = very poor 5 = excellent.

The average patient cost per day for medium-size hospitals, responding to this survey, was $4,837. This is 173 percent higher than the average patient cost per day for large hospitals, and over 350 percent higher than patient costs per day for small hospitals. This difference in average patient cost per day again highlights the similarity between large and medium hospitals while emphasizing, at least from an operational perspective, the difference between small and medium or large hospitals.

Patient and employee satisfaction scores were not all reported for the three large hospitals responding to the survey. However, the average satisfaction scores for medium and small hospitals were similar for both employee satisfaction and patient satisfaction. The average satisfaction scores for both sizes of hospitals were in the poor to very poor range.

Table 15: Descriptive Statistics by Hospital Size

	Hospital size					
	Large n=3		Medium n=5		Small n=8	
Demographics						
Item	Mean	SD	Mean	SD	Mean	SD
# of Beds.	623	133	210	41	36	29
# Pat. Admttd.	9,586	14,880	9,139	4,123	730	582
% CMS	38	8	54	10	71	15
% Uninsured.	34	40	5	5	6	5
# ER. Pat.	–	–	31,671	14,143	6,737	6,609
Independent variables						
Item	Mean	SD	Mean	SD	Mean	SD
FTE. Trnd. CI.	239	330	26	34	68	122
# of Depts.	11	14	7	12	13	8
TTU	21	8.0	17	9.0	7	5.0
TTU Efficiency	10	4.0	7	4.6	3	2.0
TTU Effectiveness	11	4.0	10	5.0	5	3.5
Dependent variables						
Item	Mean	SD	Mean	SD	Mean	SD
Avg. Lab. Wait Times	–	–	17*	15*	28*	21*
Pat. Cost/Day	$2,788	$2,192	$4,837	$2,245	$1,362	$798
Avg. Rm. Time	–	–	54*	10*	32*	38*
Errors.	–	–	2	3	1	1
Pat. Sat.	2.5**	.71**	1.6**	0.55**	1.7**	0.76**
Emp. Sat.	–	–	2.0**	0.71**	1.9**	0.38**

Note. **"–"** Indicates information not reported by more than one hospital
*In minutes **Based on a scale of 1-5 1 = very poor 5 = excellent.

4.2 Research Questions and Hypotheses Analyses and Results Summary

This section presents a summary of the results obtained when analyzing the data to test the research hypotheses developed for this study. While previous research has either studied the effectiveness of training for CI implementation (Palo & Padhi, 2003) or studied the effects of CI projects on a single performance criterion, e.g. wait times, this study was designed to examine the effects of multiple independent variables against multiple hospital performance measures.

The first step was to analyze the data to ascertain the shape of the distribution. Based upon the outcome of the analysis for the data distributions determined the statistical analysis used to analyze the data. The first analysis was to ascertain if a Generalized Linear Model could be employed to produce a predictive equation for the first three hypotheses. Next step was to determine if any associations existed between the independent and dependent variables for the first three hypotheses. This was to identify relationships that might have occurred so as to be able to make predictive statements regarding the dependent variables from the independent variables and give the hospital administrators additional tools to aid in CI decision regarding ; number of staff to train, number of departments to have involved and number of tools to use when performing CI projects.

The next analysis was performed on hypothesis four using a Wilcoxon Sign Rank test to ascertain if there was a significant difference in tool usage between effectiveness and efficiency tools. With two dominant approaches being written about within the current literature it was of interest to determine if a significant preference for one occurred over the other.

Hypothesis five was examined using Kendal rank correlations because it allowed for ranking of the data and which was different from Spearman and Pearson which do not. To add additional clarity box plots were added to exemplify the results from the Kendal analysis. The next analysis focused on summarizing the responses to the telephone interviews. Pie charts were used to illustrate these results.

The post hoc analysis was undertaken to determine if there was a significant difference in responses for small, medium, and large hospitals. Some evidence of a difference was discovered in the descriptive analysis, along with conflicting information within the literature as to whether a difference occurs and why. Finally cluster analysis was performed to determine if naturally forming clusters occurred for the use of efficiency vs. effectiveness. Both of the results from the cluster analysis and the analysis of small, medium, and large hospitals was done with a Kruskal-Wallis rank test. This test was chosen because it was the non-parametric version of a one-way analysis of variance able to analyze k numbers of variables at a time, whereas the Wilcoxon Sign Rank is a test designed to study two variables at once like a T test.

Table 16: Kendall tau b Correlation Results for Independent and Dependent Variables

	Avg. Lab Wait Times (a)	Avg. Pat. Cost/day (b)	Avg. Rm. Time (c)	Errors(d)	Pat. Sat. (e)	Emp. Sat. (f)
FTE Trnd. CI (H1)	0.35 n=8	0.43 n=7	0.22 n=5	0.47 n=5	0.12 n=11	-0.12 n=12
# of Depts. (H2)	0.08 n=8	0.04 n=8	-0.11 n=5	0.18 n=4	-0.03 n=10	-0.22 n=10
TTU. (H3)	-0.24 n=9	0.41 n=10	0.55 n=6	0.45 n=5	-0.098 n=14	-0.18 n=13

4.2.1 Summary of Analyses and Results for Hypotheses 1, 2, and 3

The distributions of data were analyzed using Minitab 15 to ascertain the shape of each distribution. If the distributions of the data were found to be normal then parametric analysis would be pursued and if not, non-parametric testing would be used. It was determined that the data were not normally distributed, and thus non-parametric statistics were used for all subsequent analysis. The research goal was to determine a predictive equation for each of six hospital performance measures based on the level of CI implementation as defined by the number of employees trained in CI, the number of departments engaged in CI, and total tool usage.

As a first step in this analysis, the level of association between each independent variable (FTE Trnd. CI, # of Depts., and TTU) and each of the six dependent variables representing hospital performance was calculated using Kendall tau b correlations. Because not all hospitals provided data for both the independent and dependent variables included in the study, the number of responses for each correlation ranged from a low of four to a high of 14. The results of this correlation analysis are summarized in Table 16. The independent variables are located in the first column of the table, and the dependent variables are located in the first row of the table using the abbreviations and acronyms summarized in Table 10. A letter designation is included next to each dependent variable consistent with the individual hypothesis associated with each dependent variable.

The lack of significant association between the independent variables and the six chosen measures of hospital performance is not consistent with some previous research, e. g. Argyris & Schon, 1996; Emison, 2004; Ishikawa, 1985; Kantor & Zangwill, 1991; Middel et al., 2006; Murray & Chapman, 2003; Rajagopalan, 1998; Zangwill & Kantor, 1998.

Prior to pursuing regression analysis scatter plots were developed and analyzed As a result, no distribution could be identified and thus no linking equation could be produced. Therefore, since the data was not normally distributed and no other distribution could be readily identified it was determined that no regression analysis would be performed on this data.

The hypotheses were, not supported with the data collected for this study. Based upon the results from the Kendal correlation analysis, the number of full time employees trained in CI tools and techniques, the number of departments involved in CI projects, and the total tools used in CI projects had no effect on wait times for lab result, patient costs per day, time to prepare a patient's room, reportable errors, employee satisfaction, or patient satisfaction for the hospitals responding to this survey. These results are not consistent with some previous research (Cua, et.al., 2001; Shah, et. al., 2001; Locke, 1979; Shingo, 1985). The question of why there was no support for these hypothesized relationships was explored further after reviewing the responses from the telephone interviews.

4.2.2 Summary of Analysis and Results for Hypotheses 4

This section discusses the research question and analyses completed to study hypothesis 4. H_4 was focused on determining whether the entire group of responding hospitals tended to favor the use of one group of CI tools (effectiveness tools or efficiency tools) over the other. Table 17 summarizes overall usage by tool number and name for the 16 hospitals responding to the tool usage portion of the survey. Tools have been sorted by frequency of use for the 16 hospitals completing this portion of the survey. The most-used tool was Benchmarking (B); with approximately 88% of the hospitals indicating that benchmarking was used in 2007. The tools, being used by at least two hospitals, but with the lowest reported usage were KBS, SIPOC, TTA, PCA, QC, and WC. Each of these tools was only used by 12% of the responding hospitals.

Table 17: Percentage of Hospitals Reporting Use of Individual CI Tools

Tool abbreviation	Percent of hospitals using tool	Number of hospitals using tool
B	88	14/16
NPET	75	12/16
CS	75	12/16
FPG	69	11/16
CFT	69	11/16
PM	63	10/16
PA	63	10/16
H	63	10/16
FBD	63	10/16
FMEA	56	9/16
CTA	50	8/16
DMAIC	50	8/16
SPC	44	7/16
PFP	44	7/16
PVA	44	7/16
VAA	38	6/16
5Y'S	38	6/16
POUS	31	5/16
AD	31	5/16
JIT	25	4/16
VSM	25	4/16
LTA	25	4/16
CRA	25	4/16
SDWT	25	4/16
5S	19	3/16
DPI	19	3/16
KBS	13	2/16
SIPOC	13	2/16
TTA	13	2/16
PCA	13	2/16
WC	13	2/16
PY	6	1/16

The next analysis examined differences in usage between effectiveness tools and efficiency tools. Effectiveness tools are CI tools associated with quality initiatives and focused on improving the quality and/or reliability of products or processes. Efficiency tools are those tools that are focused on producing improvements in the time to complete a task, the movement of people or things, the operation of teams, or the overall process efficiency. To avoid biasing the respondents, the CI tools were not grouped or categorized on the survey as efficiency or effectiveness tools.

Since DPI (Delivery Performance Improvement) was listed twice on the survey the last occurrence was not counted in the analysis. In addition, QC (Quality Circles) had zero hospitals reporting using it so it was not included in any subsequent analyses thus leaving a total of 32 tools. The remaining 32 CI tools divided evenly between effectiveness and efficiency tools, with 16 tools classified as effectiveness tools, and 16 tools classified as efficiency tools. Table 18 summarizes the usage of CI tools by category (efficiency and effectiveness) for each of the hospitals participating in this study. Overall, the usage of effectiveness tools appeared to be more prevalent for the responding hospitals. There were 121 uses of effectiveness tools; whereas only 89 uses of efficiency tools were observed. A Wilcoxon Sign Rank test was used to compare efficiency tool to effectiveness tool usage by hospital. The Wilcoxon Sign Rank test is appropriate to use when the assumptions necessary for a paired t-test are not appropriate, e.g. normality of data.

The results of the Wilcoxon Sign Rank test are included in Table 19. The Z score of -2.17 produce a significance level of .030 for the results of this test indicate that the two distributions are significantly different. In other words, hospitals were more likely to use effectiveness tools than efficiency tools. Hypothesis H_4 stating that effectiveness and efficiency tools were used equally by hospitals was not supported.

Table 18: Total Number of Hospitals Reporting Effectiveness and Efficiency Tool Usage

	Effectiveness	Efficiency
Hospital No.	No. of uses	No. of uses
15	12	10
17	7	6
7	15	14
16	15	15
1	10	5
10	2	5
8	10	2
3	13	9
14	5	4
13	9	3
5	3	0
4	9	5
6	0	1
9	3	6
11	1	2
2	7	2
Total	121	89

Table 19: Wilcoxon Rank Test Comparing Number of Effectiveness and Efficiency Tools Used

Test Statistics	
Effectiveness - Efficiency	
Z =	-2.17
Asymp. Sig. (2-tailed)	.030

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Effectiveness	16	7.6	4.87	0	15
Efficiency	16	5.6	4.41	0	15

4.2.3 Summary of Analysis and Results for Hypothesis 5

Hypothesis H_5 explored the relationship between specific tool usage and hospital performance. Kendall tau b correlations were calculated next to examine whether or not significant relationships existed between the use of individual tools and the six dependent variables related to hospital performance. This analysis was completed to ascertain if the usage of particular CI tools was associated with higher or lower performance levels. Table 20 summarizes all of the significant correlations resulting from this analysis. In some cases, the number of hospitals using a tool and/or providing performance data was small. The significant correlations included in Table 20 are only for those CI tools that were used by three or more hospitals.

Table 20: Kendall tau b Correlations for Individual Tools and Hospital Performance Metrics

Individual tools used	Lab. Wait Times (a)	Pat. Cost/Day (b)	Time Prep. Rm. (c)	Errors (d)	Pat. Sat. (e)	Emp. Sat. (f)
JIT (Effic)	-	**.606***	-	-	-	-
PA (Effec)	**-.667***	-	**.775***	-	-	-
H (Effec)	**-.671***	-	**.775***	-	-	-
FBD (Effec)	-	**.626***		-	-	-
AD (Effec)	-	-	-	-	-	**-.679***
CRA (Effec)	-	-	-	-	**-.608***	**-.679***
POUS (Effec)	**-.661***	-		-	-	-
PFP (Effic)	-	**.671***	-	-	-	-
PVA (Effec)	-	-	**.775***	-	-	-

*Correlation is significant at the 0.05 level 2-tailed

There were significant correlations between two different efficiency and seven different effectiveness tools and five measures of hospital performance. There was no significant correlation between any of the CI tools and the number of reported errors. It should be noted, that the correlation values for each tool are not completely independent. Since the same set of hospitals was used for this analysis, and since all hospitals reported that multiple tools were used. As a result, usage data are not independent. Box plots are used to visually portray the result from Kendal tau analysis. Box plots were used to explore the performance variables for hospitals using specific CI tools and hospitals not using these tools are shown in Figures 4 - 8.

There were six negative correlations identified between CI tool usage and three of the dependent variables (wait times for lab results, patient satisfaction, and employee satisfaction). Wait times for laboratory results were negatively correlated to Pareto analysis (PA), Histograms (H), and Point Of Use Stocking (POUS). Figure

4 shows that those participants that reported using Pareto Analysis, Histograms, and Point Of Use Stocking had shorter wait times than those participants that were not using the same tools. Patient satisfaction and employee satisfaction were negatively correlated with customer requirements analysis (CRA). In addition, employee satisfaction was negatively correlated to the use of affinity diagrams (AD).

The use of just in time (JIT), fishbone diagrams (FBD) and pay for performance (PFP) was positively correlated with average patient costs/day. Pareto analysis (PA), histograms (H), Pay for Performance (PFP) and process variation analysis (PVA) were positively correlated with the average room turnover time. Figure 5 illustrates the relationship between FBD, PFP, and JIT and average patient cost/day. The results indicate that those participants who reported using FBD, PFP, and JIT had higher average patient costs per day than those participants that did not use these tools. Figure 6 illustrates the relationship between the time to prepare a room and the usage of three different CI tools: PA, H, and PVA. The average time to prepare a room was longer for those hospitals that were not using these tools than for those hospitals who reported using these tools.

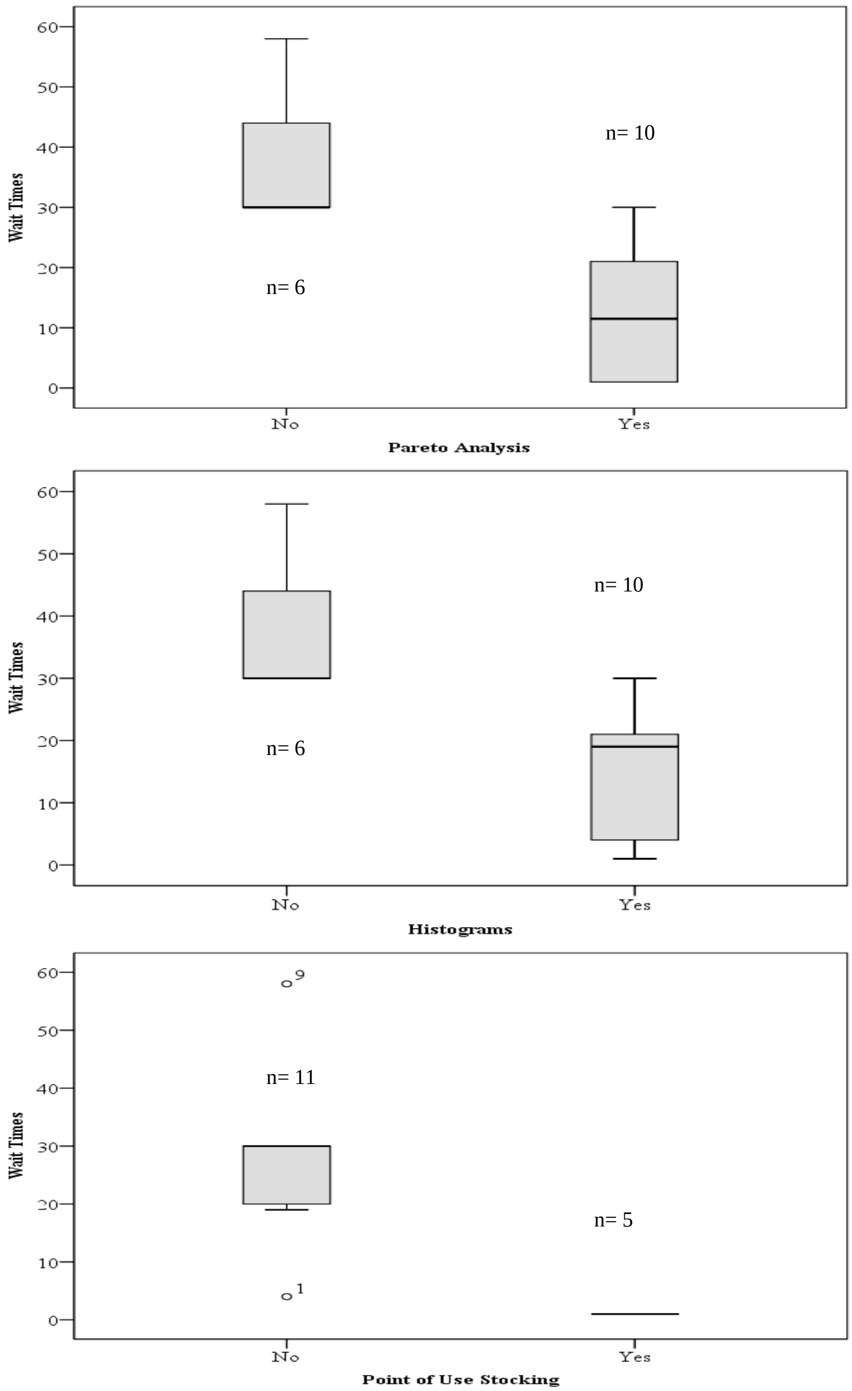

Figure 4: Box Plot Comparing Wait Times for Hospitals Using Pareto Analysis, Histograms, and Point of Use Stocking with those who did not use Pareto Analysis

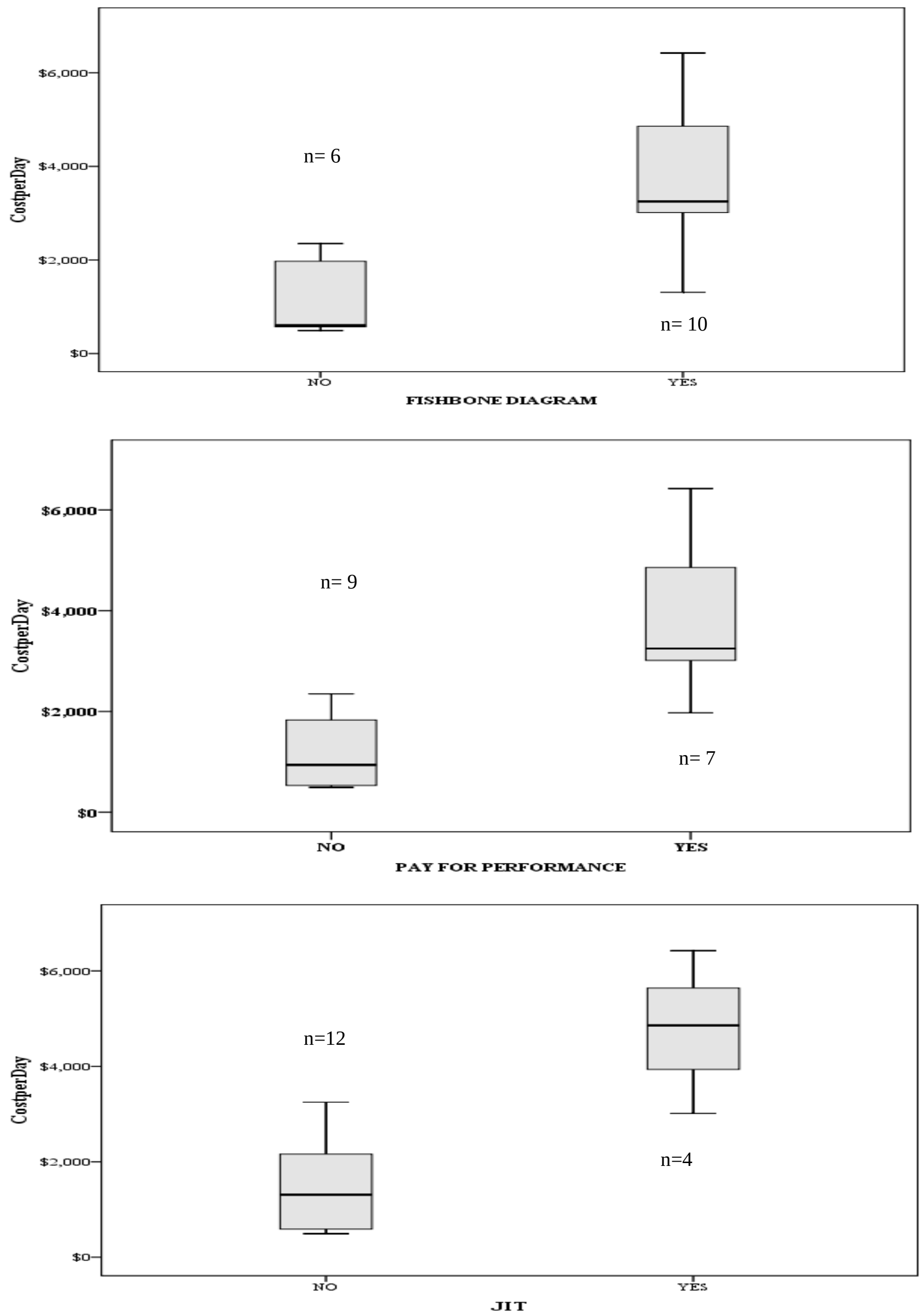

Figure 5: Box Plot Comparing Patient Costs/Day for Hospitals Using Just In Time, Fishbone Diagrams, and Pay for Performance and those who did not use these CI Tools

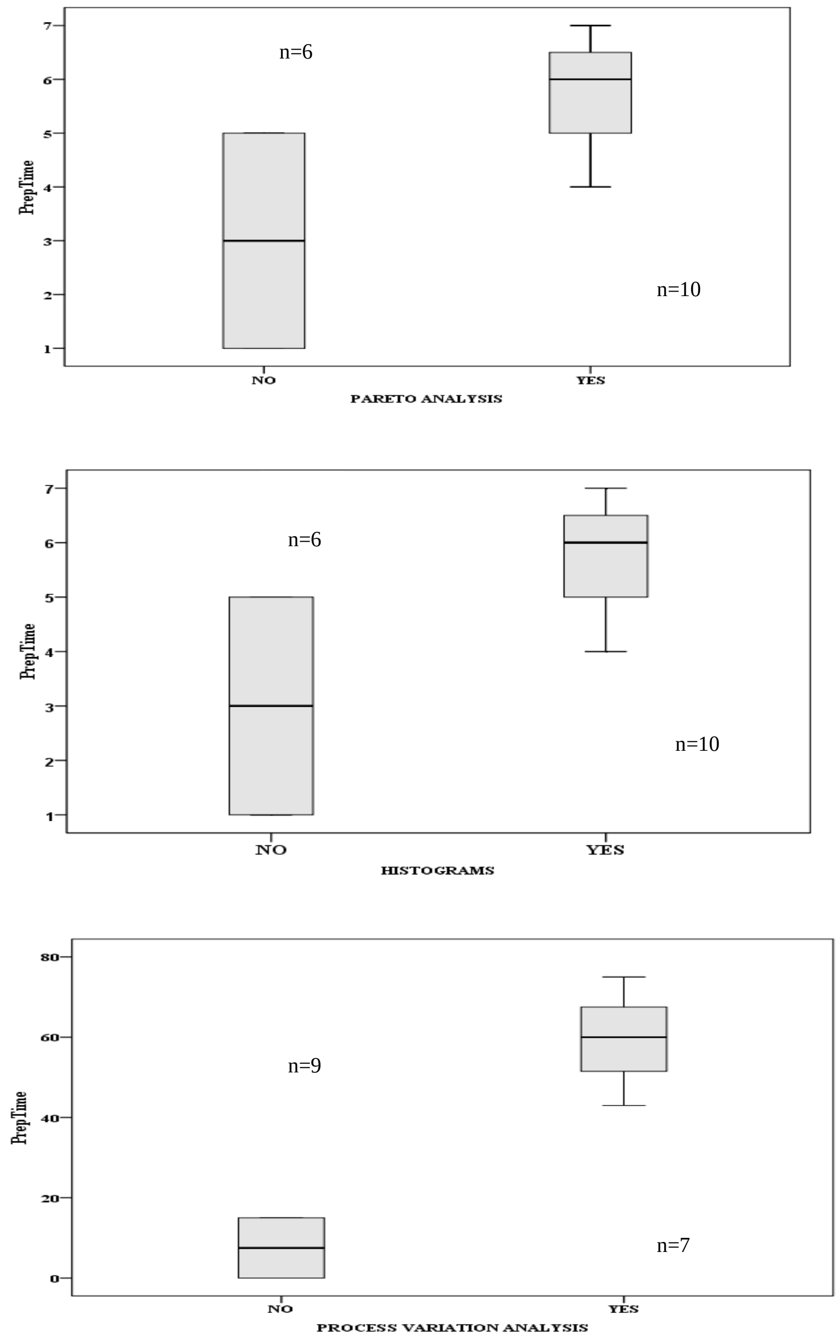

Figure 6: Box Plot Comparing Room Prep Time for Hospitals Using Pareto Analysis, Histograms, and Process Variation Analysis and those who did not use these CI Tools

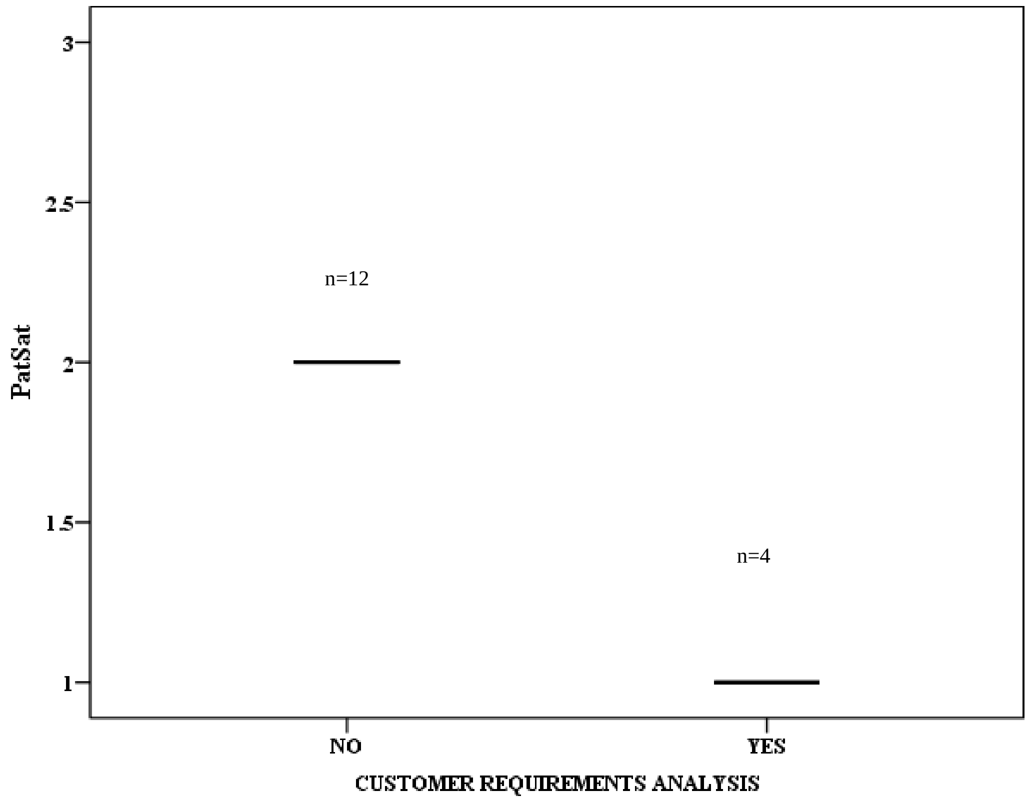

Figure 7: Pat Box Plot Comparing Patient Satisfaction for Hospitals Using Customer Requirements Analysis and those who did not use Customer Requirements Analysis

Figure 7 illustrates the relationship patient satisfaction and the usage of customer requirements analysis. The average patient satisfaction scores were higher for hospitals that were not using customer requirements analysis than for those hospitals who reported using this tool. Figure 8 illustrates the relationship between reported usage of affinity diagrams and customer requirements analysis and employee satisfaction scores. Those participants that reported not using these CI tools had higher employee satisfaction scores.

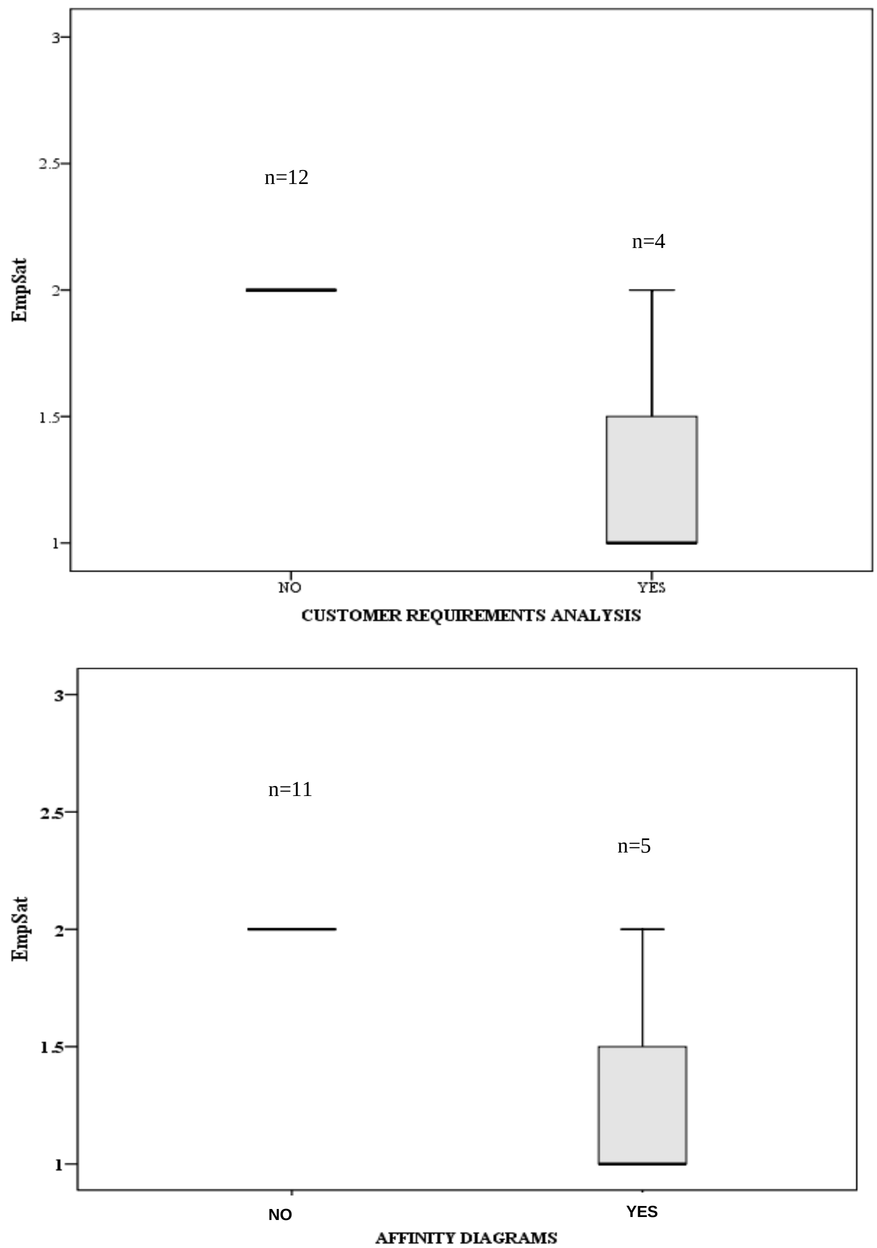

Figure 8: Box Plot Comparing Employee Satisfaction for Hospitals Using Affinity Diagrams and Customer Requirements Analysis and those who did not use these CI tools

4.3 Summary of Follow-up, Telephone Interviews

Follow-up, telephone interviews were conducted to help provide clarification on the quantitative results from the survey. The interviews were composed of seven questions and were administered to participants from nine of the hospitals. The nine participants were chosen randomly from the 17 returned quantitative surveys. Between the nine participants, all three hospital size designations (large, medium, and small) were represented.

The follow-up, telephone interview questions were designed to provide a deeper understanding of the CI programs implemented within each hospital, e.g. who was managing the programs, how the training schedule was developed, the purpose of employee training, as well as details on the departments participating in CI projects. The telephone interview results are summarized, by question, in this section.

Telephone Question 1: Part 1, who develops the training schedule? Part 2, what is the strategy for accomplishing the training? Figures 9 and 10 summarize the responses to Part 1 and Part 2.

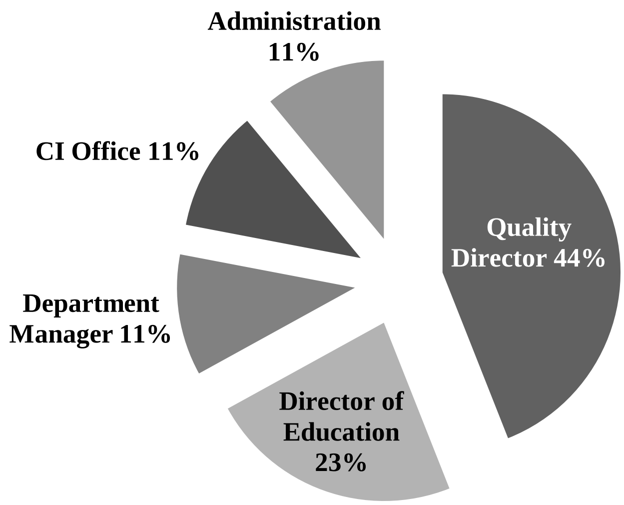

Figure 9: Who develops the training programs

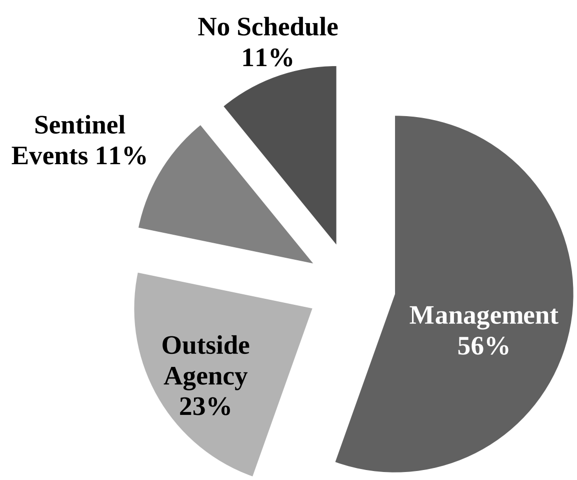

Figure 10: Strategy for accomplishing training

Telephone Question 2: Please describe the relationship, as you see it, between employees trained in CI tools and techniques and the number and complexity of CI projects? Only slightly over half (56%) of the respondents felt that there was a relationship between the number of employees trained in CI and the number of CI projects undertaken by the organization.

Telephone Question 3: Part 1, which CI projects use more tools than others? Part 2, can you describe the outcome when more tools are used? Figure 11 summarizes responses to Part 1. All of the participants felt that there was no difference in outcomes, regardless of the number of tools used in a particular CI project.

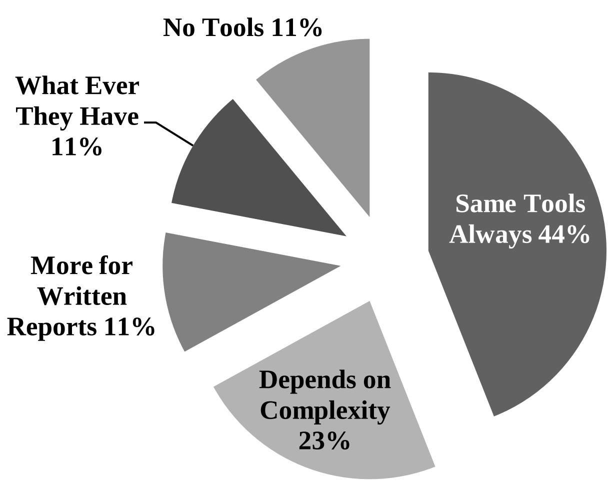

Figure 11: CI projects that use more tools than others

Telephone Question 4: Part 1, of the CI tools used, which tools are used most often? Part 2, have you noticed tool usage associated with one department or group more than other groups and why? Figure 12 summarize responses to Part 1. Of the interviewed participants, 33% stated that nursing was the department that used CI tools more than other departments. The remaining participants said that tools were used equally across departments.

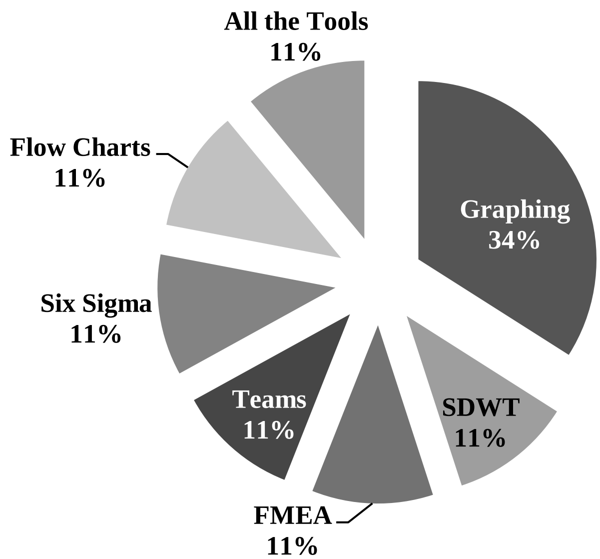

Figure 12: CI Tools Used Most Often

Telephone Question 5: How did you decide upon which CI tools to use for each CI project? Figure 13 summarizes the responses.

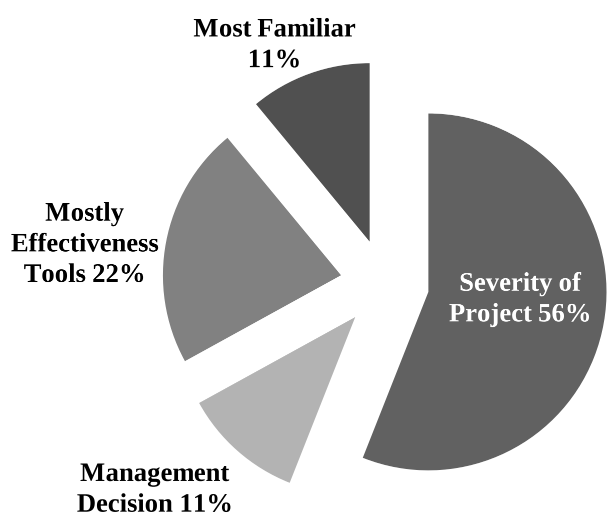

Figure 13: Decision for Choosing CI Tools

Telephone Question 6: Which departments participate in CI projects? Figure 14 summarizes the responses.

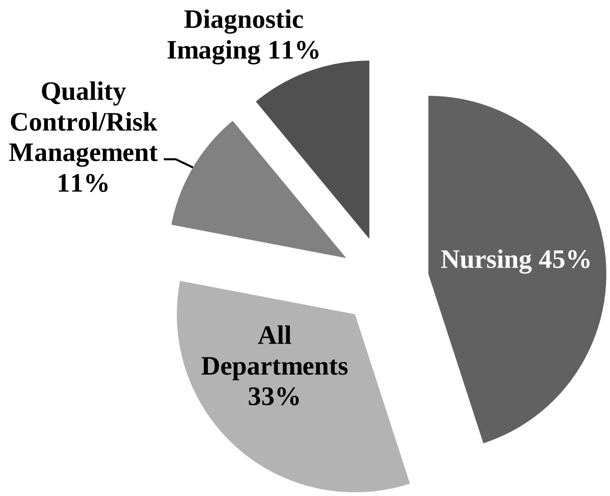

Figure 14: Department Participation in CI Projects

Telephone Question 7: Part 1, if you had to rank the participation amongst the departments, which would rank the highest in the number of CI projects undertaken? Part 2, which would rank the lowest in the number of CI projects undertaken? Figures 15 and 16 summarize the responses for Part 1 and Part 2, respectively.

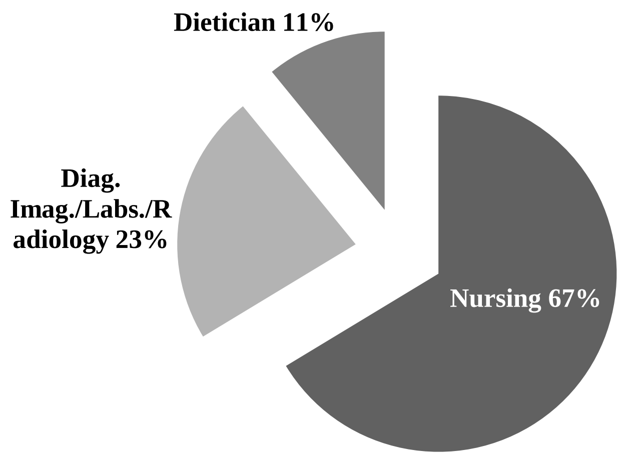

Figure 15: Departments Undertaking the Most CI Projects

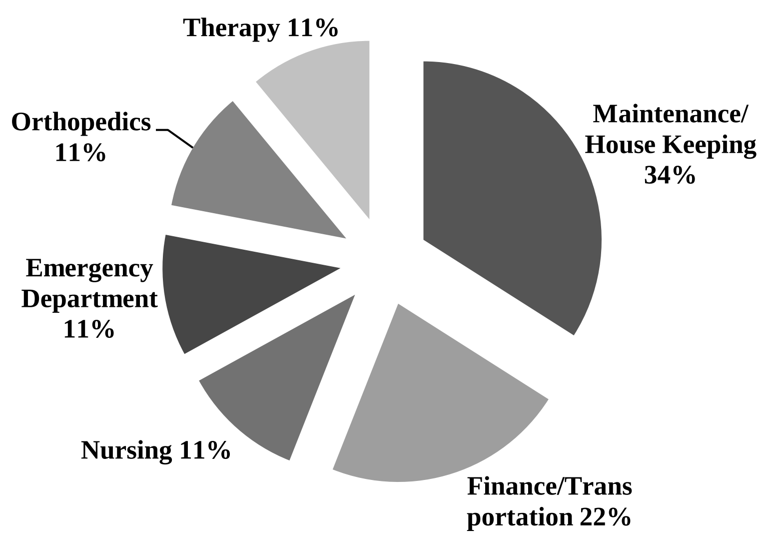

Figure 16: Departments Undertaking the Fewest CI Projects

Overall, it appears that management plays a significant role in establishing training schedules and curriculum. Over half of the participants identified a relationship between employees trained in CI tools and techniques and the number of

CI projects undertaken at a hospital. When asked about the type of CI tools used, it became clear that for most hospitals the same tools were used no matter what type of CI project was undertaken.

The tool most used as reported during the telephone interview was graphing. The second part of question 4 asked if tools were associated with specific departments, and the majority of respondents said that this was not the case. When asked how they decided upon which CI tool to use for a project the majority answered that it depended upon the urgency of the project. This is not entirely consistent with responses from question 3, where the majority of participants stated that in general, the same tools were used for all projects. When asked which departments participated in CI projects, nursing was the answer most often given. When asked to rank the departments with the highest and lowest level of participation in CI projects based on the number of projects, nursing was identified as the department with the greatest number of projects. Both maintenance and housekeeping were identified as the departments with the fewest number of CI projects.

4.4 Post Hoc Analysis Related to Hospital Size

4.4.1 Descriptive Analysis

Some previous researchers have found that the impact of CI projects on performance was moderated by the size of the hospital. In this study, three different groups of hospitals were categorized based on the number of beds. Consistent with other research, large hospitals were defined as having more than 300 beds. Medium hospitals were defined as those hospitals with 100-299 beds, and small hospitals were defined as those hospitals with 1-99 beds. The three hypotheses dominating previous research are: 1) CI projects in small organizations produce superior results, 2) CI projects in large organizations produce superior results, 3) Factors other than organizational size are important in the effectiveness of CI projects.

The first series of studies suggested that smaller facilities were more in touch with problems, more agile, less reliant on internal divisions, and better able to work cross-functionally (Guisinger & Gorashi, 2004; Lawrence & Hottenstein, 1995; Ramalingram, 1996; White et al., 1999). The researchers in these studies found that larger organizations tend to function in departmental silos with centralized organizational structures, which tended to produce organizations that were slower and less agile in decision-making.

The next grouping of research findings diametrically opposed the first grouping of studies. The results from this second set of studies found that larger institutions were better able to implement CI projects as a result of having more human and financial resources (Ismail et al., 1998; Poole, 1998; Shah & Ward, 2003). Functional organizational structures were identified as playing a necessary role in providing membership for cross-functional teams. These cross-functional teams were hypothesized to produce superior results over teams formed with participants from only one department.

The third group of researchers found that the size of the organization was irrelevant. Other factors, such as leadership, size of the CI project, number of employees involved in CI projects, and number of CI tools used were found to have a larger impact on change within an organization (Rodwell &Shadur, 1997; Sadikoglu, 2004; Taylor & Wright, 2003). Table 21 displays total tool usage for each participating hospital, ordered from the hospital using the most tools to the hospital using the fewest tools. Hospital participant numbers were randomly assigned to each participating hospital (instead of using hospital names) to ensure that survey results could not be linked with a specific hospital.

Table 21: Total tool Usage by Hospital Ranked from Most to Least Tools Used

Participant number	Hospital size	Licensed beds	Proportion total tools used	Percent of total tools used
16	Medium	250	30/32	94%
7	Large	503	29/32	91%
15	Large	766	22/32	69%
3	Medium	152	22/32	69%
1	Medium	246	15/32	47%
5	Small	25	14/32	44%
17	Large	600	13/32	41%
8	Medium	188	12/32	38%
13	Small	62	12/32	38%
14	Small	97	9/32	28%
9	Small	19	9/32	28%
2	Small	16	9/32	28%
10	Medium	215	7/32	22%
4	Small	25	3/32	9%
11	Small	19	3/32	9%
6	Small	22	1/32	3%

The greatest number of tools was used by a 250 bed medium-size hospital, participant number 16. This hospital used 30 tools out of the 32 tools included on the survey, which equates to 94 percent of the total tools. The highest tool user from the small hospitals was a 25-bed hospital. Hospital participant number 5 used 14 tools out of 32 tools or 44 percent of the tools included in the survey. This percentage is higher than one large, 600-bed hospital and higher than two medium hospitals.

4.4.2 Analysis of Size

A Kruskal Wallis test was completed to compare median tool usage by large, medium, and small hospitals. A significant difference in total tool usage (as measured by ranks) was found to exist between the large, medium and small hospitals. The Kruskal-Wallis test results are summarized in Table 22.

Table 22: Multiple Comparison of Total Tool Usage by Hospital Size

Kruskal-Wallis Results		
Chi-Square =		7.035
Asymp. Sig. (2-tailed)		.030
	N	Mean Rank
Large	3	12.83
Medium	5	10.80
Small	8	5.44

4.4.3 Cluster Analysis

Cluster analysis was undertaken next to determine if hospitals could be clustered based on tool usage patterns. This clustering was created and analyzed to determine if there was evidence that size or any identifying characteristic of the hospital emerged as being significant in the selection of CI tools. In this cluster analysis, each hospital from the study was a single case with specific tool usage data. The hierarchical cluster analysis results support the existence of two clusters of users, one with four hospitals and the second cluster with the remaining 12 hospitals. Table 23 summarizes total tool usage and the breakdown of effectiveness and efficient tool usage for each hospital by cluster. The dendrogram from this cluster analysis is shown in Figure 17.

Table 23: Descriptive Analysis of Two Cluster Groups

	Participant Number	Hospital size	Total tools	Effectivene ss	Efficiency
Cluster 1	15	Large	22	12	10
	7	Large	29	15	14
	16	Medium	30	15	15
	3	Medium	22	13	9
	Total		103	55	48
	Median		26	14	12
Cluster 2	17	Large	13	7	6
	1	Medium	15	10	5
	10	Medium	7	2	5
	8	Medium	12	10	2
	14	Small	9	5	4
	13	Small	12	9	3
	5	Small	3	3	0
	4	Small	14	9	5
	9	Small	9	3	6
	11	Small	3	1	2
	2	Small	9	7	2
	6	Small	1	0	1
	Total		107	66	41
	Median		9	7	4

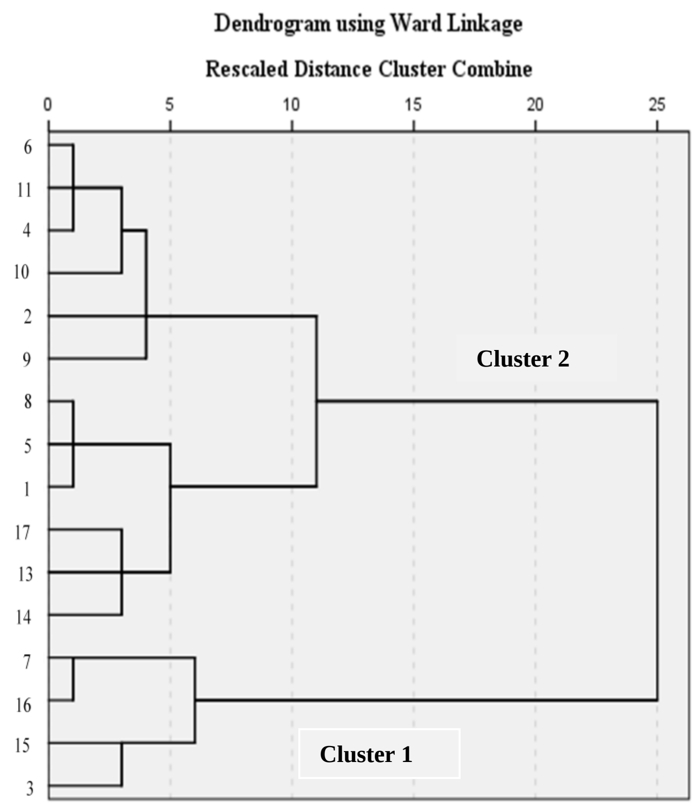

Figure 17: Dendrogram of Hierarchical Cluster Analysis of Tool Usage by Hospital Clusters

To identify if a significant difference existed between clusters, a Kruskal-Wallis test was performed. There was a significant difference in total tool usage between these two clusters of hospitals, with cluster one using more tools than cluster two. In addition, there was a significant difference between the number of efficiency and effectiveness tools used for cluster two and cluster one, with cluster one using significantly more efficiency and cluster two more effectiveness tools. The Kruskal-Wallis test results are summarized in Table 24.

Table 24: Comparison of Tool Usage by Cluster

	Effectiveness Tool Usage	Efficiency Tool Usage	Total Tool Usage
Chi-Square =	8.533	8.584	8.559
Asymp. Sig.	0.003	0.003	0.003

In summary, post hoc analysis identified that there was a difference in tool usage between small, medium and large hospitals. There was also evidence for a significant difference between total tool usage, effectiveness tools, and efficiency tool usage between the two clusters of hospitals identified. It is also notable that four of the hospitals participating in this study accounted for almost half of the reported tool usage.

4.5 Summary

In summary, based on the data collected from the 16 hospitals responding to the web survey, there was support for the following hypotheses: $H_{\mathbf{4}}$ (Are hospitals equally likely to use effectiveness and efficiency tools in CI projects) and $H_{\mathbf{5abcef}}$. (the use of individual CI tools in CI projects has an effect on:

H_{5a} wait times for lab results.
H_{5b}: patient costs/day.
H_{5c}: times prepare a room.
H_{5d}: reduction in number of reportable errors.
H_{5e}: overall rating for patient satisfaction for the hospital.
H_{5f}: overall rating for employee satisfaction for the hospital.)

Other hypotheses remain unsupported. There was a statistically significant difference in the adoption of effectiveness and efficiency tools by the hospitals participating in this study. TTU does appear to be related to hospital size, i.e. small, medium, and large or possibly to other characteristics. In the next and final chapter, these results are discussed in the context of previous research, and where possible, conclusions are drawn from these results. Implications for hospital administrators are also discussed, and possible future research areas are identified.

5 Discussion

Chapter 5 is divided into six sections: summary of the study, findings, conclusions, limitations, implications for administrators, and future research. The summary is comprised of three sections: the research problem, a review of related previous research, and a summary of the research questions. The second section presents the findings from this dissertation. The conclusion section highlights three key findings resulting from this study. The fourth section is implications, and it identifies three limitations found within this research. The implication for administrators section summarizes four results relevant to practicing administrators relative to the use of CI tools in hospitals. The final section is devoted to suggestions for future research, focusing on four specific areas.

5.1 Summary of the Study

The overarching driver for this study was, “Why has health care not made the same scale of progress in reducing errors, reducing costs, improving patient throughput i.e. wait times, and increasing employee and patient satisfaction, in comparison with other industries, e.g. the automotive industry. Crossing the Quality Chasm (2001) outlined 13 areas of concern and made recommendations for needed improvements within health care. Of those 13 areas of concern, five were considered in this study and formed the basis for the selection of six dependent variables. The dependent variables, identified for use in this study as measures of hospital performance were:

1. wait time for lab results

2. patient costs/day
3. time to prepare a room
4. number of reportable errors
5. overall patient satisfaction rating
6. overall rating employee satisfaction

The independent variables chosen for this study were derived from a review of previous research on organizational performance, taken from both the academic literature as well as practitioner literature in both healthcare and manufacturing. The five independent variables determined to be relevant from this review of the literature were the number of employees trained in CI tools, the number of departments involved in CI projects, the total number of CI tools used in CI projects, type of tool used (effectiveness or efficiency), and the specific CI tool used. From this same review of literature, two types of CI projects and tools emerged.

The first type of tools and projects was associated with TQM/Six Sigma and included CI tools focused on improving organizational effectiveness. Many of these tools developed out of the writings of Deming, Juran, and Shingo. The second type of tools and projects was associated with Lean Manufacturing and included CI tools focused on improving organizational and process efficiency. Many of these tools were developed from work at Toyota and descriptions of these were summarized by researchers such as Womak, Jones and Ohno.

The literature review produced the foundation for understanding the research problem and ultimately led to the generation of the five research questions:

1. Does the number of full-time employees trained in CI tools effect hospital performance?

2. Does the number of departments involved in CI projects effect hospital performance?
3. Does the number of tools used in a CI project effect hospital performance?
4. Do hospitals only use either effectiveness or efficiency tools in CI projects?
5. Does the use of a particular CI tool in a CI project effect hospital performance?

5.2 Summary of the Findings

A total of 206 hospitals from three states (Idaho, Oregon, and Washington) were invited to participate in this study. The data for the study were collected using a custom-developed web survey. There were six fully-completed and 11 partially-completed surveys returned. Of the 17 returned surveys only 16 were included in the data analysis, which corresponds to a response rate of less than eight percent. Performance and tool usage data from 2007 were used in all analyses. The only three large hospitals to respond to the request for participation were located in Oregon. The largest number of surveys was returned from hospitals in Oregon. The section of the web survey with the highest rate of completion was the section that elicited responses about different reasons for using CI projects. The section of the survey with the lowest rate of completion was the section requesting actual performance data. Similarities in response values for both dependent and independent variables was noted between medium and large hospitals.

5.2.1 Summary of Results Related to Hypotheses 1 - 3

Testing for H_1, H_2, H_3 began with calculation of Kendal tau b correlations between each independent and dependent variable. No significant correlations were found. A review of scatter plots of each of the dependent and independent variables did not identify any linearity or other identifiable relationship. Given these results, further analysis on regression modeling was not deemed to be appropriate.

Number of full time employees trained in CI practices, number of departments involved in CI projects, and the total number of tools used was not found to be related to any of the six dependent variables. These results are not consistent with more targeted previous research that has shown that a wider range of tool usage and greater involvement by all departments is related to problem resolution (Rodwell & Shadur, 1997; Sadikoglu, 2004; Taylor & Wright, 2003; Zangwill & Kantor, 1998).

Similarly, the number of trained employees had no significant relationship with any of the six dependent variables in this study. These findings do not support results from previous studies in healthcare, which have shown a relationship between training and employee satisfaction and other performance measures including turn times of rooms (Poole, 1998), error reduction (Carman et al., 1996), and customer satisfaction and employee satisfaction (Ramalingam, 1996).

The limited number of participating hospitals resulted in a very narrow range of response. Since the responding number of hospitals was so small it is possible that the data from this study only represents a subset of the larger population. So, while the lack of evidence relating the independent and dependent variables appears to support a conclusion of no relationship, theses findings should not be generalized beyond respondents and it is possible that these findings do not generalize across a large population.

5.2.2 Summary of Results Related to Hypothesis 4

H_4 examined tool usage patterns by hospitals. Based on the analyses completed, there is evidence that for the hospitals participating in this study that a significant preference existed for using effectiveness tools. However, even with the preference for using effectiveness tools, all of the responding hospitals also reported using at least some efficiency tools, albeit a smaller number. Previous research has found that using a mixture of effectiveness and efficiency tools is advantageous (George, 2002; Wedgewood, 2007).

The higher level of effectiveness tool usage may be an artifact from the history of CI in health care. In particular, TQM and Six Sigma have been deployed for a longer period of time than efficiency tools. Tool usage data summarized from the survey was consistent with telephone interview responses, which in summary found that the tools most often used were ones that were most familiar to the organization and had been used in previous CI efforts.

5.2.3 Summary of Results Related to Hypothesis 5

The analysis of $H_{5a\text{-}f}$ was undertaken next. These hypotheses were developed to test the effect of individual CI tools on various aspects of hospital performance, as measured by the six dependent variables included in this study. With the exception of wait times for lab results, the findings from this study were contrary to previous research in the manufacturing and healthcare domains. For example, patient cost per day was correlated to just-in-time, pay for performance, and fishbone diagrams, in such a way that indicated that as the usage of these tools increased so did the patient costs per day. In one previous study, for example, Cua et al. (2001) found that higher levels of manufacturing performance could be expected when the different practices and basic techniques of TQM, JIT, and TPM were implemented together. Further, they were able to show that jointly, these combined practices or techniques were responsible for significant improvements, including cost reduction, conformance to quality, volume flexibility, and on-time delivery. Although these manufacturing metrics are closely related to hospital performance measures used for this study, the findings from this study were not similar.

Overall, while there was evidence for significant relationships between tool usage and hospital performance, the direction of the findings did not support previous research except for one set of relationships. In general, the findings from this study indicated that hospitals not using certain CI tools performed better than those hospitals using tools. Support was found for all of the hypotheses with the exception of reduction in reportable errors, which did not have significant relationship to any of the CI tools listed in this study. Given the small number of respondents who provided performance data it could be that the hospitals using tools are currently doing so because of poor performance in a particular area. It is possible that the wrong tools are being used to address performance improvement. It is possible that tools are being chosen on the basis of familiarity rather than its appropriateness for accomplishing the task. It is possible that if this is happening, as reported in the telephone survey, then this inappropriate tool usage could possibly explain the negative relationships found when tools were used.

The hospitals responding to this study did not represent the population of hospital clinical staff in the US based upon hospital size. Most of the respondents were employed in small hospitals. Small hospitals have fewer resources and personnel. Thus, it is possible that many of the respondents were still in the early stages of CI tool adoption and were not mature in their understanding of how best to apply CI tools to improve performance. If these hospitals were fairly immature in the use of CI tools, personnel may not be fully trained or knowledgeable in the application of CI tools, thus it is not possible with this dataset to rule out maturity as a confounding factor. A second notable caveat to these findings is that data related to the length of CI tool usage and CI activities were not collected. In addition, respondents were not asked to match specific CI tools to targeted results. Thus, it is possible that implemented tools were never directly applied to the performance areas included in this study.

5.2.4 Summary of Results from Follow-On Telephone Interviews

Analysis of the data from the telephone interviews provided some interesting insight and helped characterize some aspects of CI adoption in the participating hospitals. Some of the key insights were that there was, in general, a lack of involvement by employees in the decision process for training and lack of employee involvement in scheduling of training. Management was most often cited as being responsible for establishing the training schedule and determining who was to be trained. Further, it appeared that those leaders interviewed did not match specific types of training with specific CI projects or specific performance improvement objectives.

There was evidence from the phone interview that general involvement in CI was limited. The departments most frequently engaged in CI projects were the clinical departments of nursing, laboratory, and imaging. Nursing was identified the most often as involved in CI projects. Non-clinical departments appeared to be the least involved in CI projects. Housekeeping, maintenance, and accounting were identified the most often as not involved with CI projects.

5.2.5 Summary of Results Related to the Impact of Hospital Size

The last analysis undertaken was to ascertain if response patterns were the same or different for large, medium, and small hospitals. Kruskal-Wallis test results did support a significant difference in the number of CI tools used between small, medium, and large hospitals. These findings are not consistent with previous research in manufacturing organizations that have found that size of organizations has no effect. Other factors such as leadership, size of the project, number of employees, and number of practices have a greater effect (Rodwell & Shadur, 1997; Sadikoglu, 2004; Taylor & Wright, 2003).

Continuing to investigate further, a hierarchical cluster analysis by hospital was performed. Two distinct clusters were identified. The cluster group containing four hospitals was composed of two large and two medium hospitals, while the second cluster group contained mostly small hospitals. A Kruskal-Wallis test was then performed to ascertain if there was a significant difference between the two clusters. The results indicated that a significant difference in tool usage existed with the small cluster of larger hospitals showing significantly greater tool usage than the larger cluster of small hospitals. The next section presents the conclusions derived from these significant findings.

5.3 Conclusions

Three significant discussion points were raised as a result of this study. First, the number of full time employees trained in CI tools, the number of departments involved in CI projects, and the number of CI tools used in CI projects appeared to have no effect on wait times for laboratory results, patient costs, time to prepare a patient's room, number of reportable errors, or patient satisfaction. These results suggest that hospitals may not be similar to manufacturing organizations. If the flow of work is considered, hospitals are more similar to repair stations or depots. Like repair depots, hospitals receive damaged products (patients) that come in with incomplete histories, at least as known by the staff. Both depot repair engineers/technicians and physicians resort to problem solving diagnostics to understand and correct problems, and both (engineers/technicians and physicians) rely on established mental models to resolve problems. Applying manufacturing models for CI tool usage to a repair depot setting may not be appropriate. The unique results of this study suggest that perhaps the analogies made between manufacturing operations and performance improvement are not appropriate in a health care setting. Different models for CI tool application and CI activities may be needed.

The analysis completed related to organizational size was also interesting. In small organizations, including hospitals, staff members must often perform a more diverse set of tasks because of the smaller number of individuals within the organization. Small organizations, unlike larger organizations can not divide tasks up between great numbers of personnel. It may be that for small organizations, it is more difficult to apply CI tools than it is for larger organizations with their additional economic and employee resources.

The second point is that the hospitals participating in this study used both effectiveness and efficiency tools on CI projects, with a bias towards the use of effectiveness tools. Thus, it could be concluded that hospital personnel appear to prefer a mixture of efficiency tools and effectiveness tools regardless of the types of CI projects and/or performance improvements being sought. This phenomenon may reflect that for some hospitals, the use of CI tools and the selection of CI tools is not done as a strategic process, but rather is based on individual manager preferences or previous experiences with tools. In addition, there appears to be a lack of employee involvement in planning for training of employees. Management, based upon the interviews, identified all the training topics and scheduled CI training. Most of the respondents answered that they used tools they were most familiar with and did not necessarily select CI tools with a specific purpose in mind.

The results of the telephone interview clearly indicated a controlling of training and project selection by management. It is possible that since management is choosing the projects, only those projects that are important to management are receiving attention and support. Further, it is also possible that management is not making a clear one to one correspondence between clinician skills and the complexity of the CI project. Therefore, it is possible that clinicians without the proper training are completing some projects. This may be the reason for the unexpected correlations and could explain the use of effectiveness tools even when the project might require efficiency tools.

Third, the results indicated that with the exception of pareto analysis, histograms and point of use stocking methods and their positive effect on wait time for lab results, those participants who did not use these CI tools had superior results. These results may be symptomatic of a more generalized lack of understanding in the use of CI tools or incomplete knowledge of CI practices. The data collected does not allow for determining the sequence in which CI tools were adopted or how they were applied. Early adoption of effectiveness tools may be one reason for using known tools rather than branching out and using the tools which might be better suited for reaching certain goals and this could explain the usage patterns observed in this study. When confronted with a new experience, humans will often tend to utilize solutions that require the use of known commodities, in this case CI tools, which they have used before and are comfortable using (Bandura, 1969).

In summary, the data from this study appears to suggest a limited effect of the independent variables on the dependent variables. Second, it appears that hospital personnel prefer effectiveness tools. Respondents may lack a clear understanding of how to select tools for specific uses or for strategically selecting tools to support overall performance goals. Finally, it appears that with management selecting the projects, the match between tool knowledge and project needs may not be well aligned, and this could be responsible for the anomalous correlations observed.

5.4 Limitations

There were three main limitations to this research. The first is that no direct question was asked to tie tool usage to any of the metrics. Thus, it is impossible to know with any certainty whether the unusual correlations occurred because of specific tool use or if these correlations were coincidental in nature.

The second limitation is that no data were collected to identify the level of maturity these respondents were at with respect to their use of CI tools or with respect to a CI program. Such may have been helpful in understanding if preferences for effectiveness tools was based on familiarity or based on the type of CI projects being undertaken.

The third limitation was that half of all of the participants were from small hospitals, which biased the data set. As a result, characteristics that might be attributed to small hospitals in staffing, culture, and patient population might have factored into the results observed in this study.

5.5 Implications for Administrators

There are four salient points that emerged from this study that are important to administrators of hospitals. The first point comes from the apparent lack of involvement in CI projects by some clinical and non-clinical staff. Nowhere was this more evident than in the results of the telephone interview. Nursing was identified as the group most often involved in CI projects. However, of the six dependent variables used to measure hospital performance, only patient satisfaction and reportable errors are directly linked to nursing functions. Reportable errors are not just the sole responsibility of nursing, pharmacy or laboratory personnel, physicians also play an important role in this important metric.

Of the other four dependent variables, departments other than nursing have a major role in determining the outcome of any improvement activities, e.g. accounting has the talent and skill base to provide meaningful insight into reducing patient costs/day. However, these departments were reported to be least involved in CI projects. Nursing cannot be responsible for all of the improvements needed in a hospital, thus involvement by other departments and personnel are needed for hospitals to improve across a wider range of performance metrics.

The second point relevant to administrators gained from this research is the establishment of a professional training program. The apparent lack of understanding of the relationship between tool usage and specific CI projects and goals was evident in both the web survey and the telephone interviews. The fact that four hospitals used almost half of all of the tools is significant. Training should take into account the project goals when identifying who is to be trained and what training is needed. In addition, the training program should be professionally executed. Professional trainers are needed to understand the complexity of instructing adults along with the intricacies of the tools being introduced in the training. Trainers must also possess an understanding of the needs of the hospital, which should not be overlooked when establishing the training schedule and lesson plans. Consistency is another key to longer term success and provides the last reason for using professional trainers to train those members designated by management. Once trained, each staff member will have the same knowledge and work with the same tool set thus enabling a greater number of interdepartmental teams to be formed.

In addition, a team of individuals should be able to select the package of tools to be used for a project across a hospital. This team should include, but not be limited to, managers, clinicians, and a professional trainer (one who knows both efficiency and effectiveness tools and practices). Once the tool package has been selected, all clinical staff should be trained in tool usage in order to provide the necessary basic knowledge needed to troubleshoot and resolve problems, rather than relying on mental models or outdated experiences. This same effort should also be applied to the non-clinical staff in order to enable involvement of non-clinical personnel in solving problems. There should be no expectation that the tools for clinical and non-clinical personnel should be the same.

The third point is related to the lack of response from hospitals even with repeated requests for information. Of the 17 hospitals out of 206 that chose to respond, many hospitals chose to not respond to the request for reportable error data. *Crossing the Quality Chasm* included a call for more open and honest communication within healthcare. One of the many suggestions that came out of this monograph was the need to eliminate a blame approach for errors and the need to foster a more open dialogue within and between hospital personnel. Over 98,000 deaths each year are due to preventable errors within hospitals (IOM, 2001). Administrators should take the first steps within their organizations and between hospitals to share error information. It is only through the sharing of successes and failures that an organization can move from single loop to double loop learning and to transcend the individual based learning to learning that becomes part of the organization (Argyris & Schon, 1996).

The fourth implication for administrators is that of cultural change. Continuous Improvement (CI) is a cultural change and to not treat it so could result in incomplete adoption and lackluster results. There are several fundamental tools that are crucial to a successful implementation of a program of change. Without utilizing these tools it is unlikely to attain a complete cultural change.

During the telephone interviews at no time were questions directly asked regarding CI as a cultural change activity. However, at no time was CI ever referred to by the participants as a cultural change. It is possible to extrapolate from the comments of the respondents that CI was not viewed as a cultural change and that these essential tools were not employed.

There are four essential constructs for CI change implantation which are reviewed in this section. The first construct is to review the mission, vision, and values statements of the organization regularly. This is necessary to remind employees of the organization's goals, direction the organization is going, and the organization's core beliefs. The vision statement should make reference to the change process. The mission, vision, and values, were never incorporated into any answers leading to speculation that they are not being reviewed regularly.

The second essential construct is to create a crisis. Without a crisis, change will not occur. Why change when nothing appears to be wrong? Change requires people to respond to situations differently than they may have in the past. It often takes an external stimulus to make that change in behavior occur (Bandura, 1969). During the telephone interviews, the only time crisis was mentioned was that it was used as the reason for a CI project, not that the hospital was in a state of crisis because of some problem. The crisis was viewed as something to resolve so that the organization could move on to more regular daily activities.

The third construct is employee empowerment. Employees are the individuals that will carry out the change and use CI tools to solve problems. It was evident from the answers to several questions that management set the agenda for CI projects, not the employees. In addition, training was controlled by management without any employee input. This is not an empowered decision making staff.

Without the staff being empowered to seek out opportunities for applying CI tools for change , CI changes will not occur and CI will not become a cultural change.

The fourth and final construct is the rewarding of small gains and the publication of these gains for all employees to read. This technique is referred to as shaping, where the rewarding of successive approximations to the desired behavior occur (Bandura,1969). If the little gains are not reinforced, the big gains may never occur. If the big gains do not occur, then CI will not occur either. None of the respondents mentioned any strategies for sharing CI projects success. In fact, most of the respondents had little detailed information on the status of current CI projects within their organization.

In summary, there was no evidence found to confirm that the implementation of a consistent plan for change incorporating CI was in place in any of the respondent's organizations. This could explain the lack of progress health care has made over the last two decades as opposed to the improvements witnessed in other industrial sectors during this same time period.

5.6 Future Research

While this research suffered from lack of participation that greatly limited the ability to generalize the results, the research has created a foundation for future study. One area for future research and three research questions were identified as a result of this study. The area identified is what appears to be a lack of involvement by the general staff in selecting projects. The telephone interviews indicated that management or some type of event was the precipitating event for a CI project. This also led to a lack of understanding of what CI projects were occurring and implied a chaotic atmosphere in which CI projects are occurring. Involvement is key to both CI and to employee satisfaction (Locke & Latham, 1990; Shingo, 1981). Research into involvement and its relationship to CI project outcomes is needed. In addition, the relationship between involvement and nurse satisfaction should be investigated. With the crucial shortage of nurses and nurses prematurely leaving, it is important to understand this relationship.

The first question for future research was developed based upon the stated lack of engagement in CI projects by some clinical and in many non-clinical departments. Why have so many departments not adopted CI tools and techniques the way that nursing was reported to have adopted these tools? What is the difference between nursing and other clinical departments that makes nursing engaged in CI projects and other departments to be disengaged?

The second question for future research was related to the level of engagement in CI activities of clinical departments and the effect that may have on reportable error reduction. Does the level of engagement from clinical departments vary from hospital to hospital and does the level of engagement by clinical departments have an effect on the reduction of reportable errors?

The third and final question for future research was developed as a result of the observed difference in tool usage between small, medium, and large hospitals. Small hospitals have fewer staff and are often responsible for a more diverse set of activities than employees of larger, better staffed hospitals. In addition, in larger hospitals, adding training resources may be available. Is it this difference in staffing levels that produces the observed differences in tool usage between different sized hospitals?

In summary, the selection and the successful implementation of CI tools in health care present health care managers and industrial engineering professionals with a challenge. In addition to identifying a performance area to address, organizations must also develop a process for identifying the CI tool or sets of CI tools that will have the most significant impact and develop a process for deploying the tools in the best way possible within the organization. This study adds to the existing body of knowledge related to the use of CI tools and implementation practices by looking at how hospitals in the states of Idaho, Oregon, and Washington have navigated these challenges. In addition, this study also contributes to the existing literature by providing a summarized set of data to characterize the usage and deployment of CI tools in hospitals.

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APPENDICES

Appendix A

HOSPITAL IMPROVEMENT SURVEY
A DISSERTATION STUDY FOR OREGON STATE UNIVERSITY
BY
JOHN HOLLIDAY

Thank you for participating in this study. I know that your time is valuable and this survey should only take 30 minutes to complete the first three sections.

There are four sections to this survey. In sections one through three, each question will ask you to respond for the years 2006 and 2007.

Section four has two open ended questions and is an opportunity for you to provide your ideas regarding continuous improvement (CI) activities within the hospital setting.

Thank you in advance for your time. The results from your survey will be summarized and at the conclusion of the study e-mailed to you.

Section I

Please fill-in the blanks.

==

1. What is the name of your

   hospital____

2. How many licensed beds did your hospital have in:
   2006_____________
   2007_____________

3. How many patients were admitted to the hospital in:
   2006_____________
   2007_____________

4. Of the patients admitted, what was the percentage of Medicare and Medicaid patients in:
   2006_____________
   2007_____________

5. Of the patients admitted, what was the percentage of uninsured in:
   2006_____________
   2007_____________

6. How many patients were seen in your ED (Emergency Department) in:
   2006_____________
   2007_____________

7. How many full time employees did the hospital have engaged in CI, e.g. Six Sigma, Lean, TQM, or other CI process etc. in:
2006____________
2007____________

8. How many departments within the hospital were engaged in CI, e.g. Six Sigma, Lean, TQM, or other CI process etc. in:
2006____________
2007____________

9. How many full time employees have been trained in CI, e.g. Six Sigma, Lean, TQM, or other CI process etc. in:
2006____________
2007____________

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Section II

The following 6 questions ask about your hospital's activities in (Six Sigma, Lean, TQM, or other CI process etc.).

==

1. Was the hospital's staff engaged in CI, e.g. Six Sigma, Lean, TQM, or other
CI process to decrease patient costs in
2006 yes no
2007 yes no

What was the average cost per patient day in
2006____________
2007____________

2. Was the hospital's staff engaged in CI, e.g. Six Sigma, Lean, TQM, or other CI process to decrease lab result wait times in
2006 yes no
2007 yes no

What was the average wait time for lab results in
2006____________
2007____________

3. CI Was the hospital's staff engaged in CI, e.g. Six Sigma, Lean, TQM, or other process to reduce patient room prep time in
2006 yes no
2007 yes no

What is the average time to prepare a patient room in
2006_____________
2007_____________

4. CI Was the hospital's staff engaged in CI, e.g. Six Sigma, Lean, TQM, or other process to reduce reportable errors in
2006 yes no
2007 yes no

What was the number of reportable errors in
2006_____________
2007_____________

5. CI Was the hospital's staff engaged in CI, e.g. Six Sigma, Lean, TQM, or other process to improve patient satisfaction in
2006 yes no
2007 yes no

What was the overall patient satisfaction rating for the hospital on a scale of 1 to 5 (with Very Good = 5, Good = 4, Average = 3, Poor = 2, Very Poor =1) in
2006_____________
2007_____________

6. CI Was the hospital's staff engaged in CI, e.g. Six Sigma, Lean, TQM, or other process to improve employee satisfaction in
2006 yes no
2007 yes no

What was the overall employee satisfaction rating for the hospital on a scale of 1 to 5 (with Very Good = 5, Good = 4, Average = 3, Poor = 2, Very Poor =1) in
2006_____________
2007_____________

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Section III

Section III is comprised of 34 questions, requiring your use of CI practices for 2006 and 2007.

It is important that all of the questions are answered to provide your organization with an accurate comparative analysis at completion of the study.

If any term is not understood, click on the term and the link will take you to the definition

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Did you use the following tools/techniques as part of your organization CI efforts?

1. 5S
   2006 yes no
   2007 yes no

2. Mistake Proofing (Poka-Yoke)
   2006 yes no
   2007 yes no

3. New Processes and Equipment Technology
   2006 yes no
   2007 yes no

4. JIT (Just In Time)
   2006 yes no
   2007 yes no

5. Cycle Time Analysis
   2006 yes no
   2007 yes no

6. POUS/POS (Point Of Use Stocking)
   2006 yes no
   2007 yes no

7. Kanban System
   2006 yes no
   2007 yes no

8. Value-Added Analysis
   2006 yes no
   2007 yes no
9. Value Stream Mapping
   2006 yes no
   2007 yes no

10. Process Mapping
    2006 yes no
    2007 yes no

11. SIPOC (Supplier Inputs Process Output Customer) Analysis
    2006 yes no
    2007 yes no

12. Lead Time Analysis
    2006 yes no
    2007 yes no

13. Delivery Performance Improvement
    2006 yes no
    2007 yes no

14. Travel Time Analysis
    2006 yes no
    2007 yes no

15. Process Capability Analysis
    2006 yes no
    2007 yes no

16. SPC (Statistical Process Control, including control charts)
    2006 yes no
    2007 yes no

17. Pareto Analysis
    2006 yes no
    2007 yes no

18. Histograms
    2006 yes no
    2007 yes no

19. Frequency Polygons (Line Charts)
    2006 yes no
    2007 yes no

20. Fishbone (Ishikawa) Diagrams
    2006 yes no
    2007 yes no

21. DMAIC (Define, Measure, Analyze, Improve, and Control)
    2006 yes no
    2007 yes no

22. Affinity Diagrams
    2006 yes no
    2007 yes no

23. FMEA (Failure Mode Effect Analysis)
    2006 yes no
    2007 yes no

24. 5 Why's
    2006 yes no
    2007 yes no

25. Customer Requirements Analysis
    2006 yes no
    2007 yes no

26. Customer Surveys
    2006 yes no
    2007 yes no

27. Benchmarking
    2006 yes no
    2007 yes no

28. SDWT (Self Directed Work Teams)
2006 yes no
2007 yes no

29. Cross Functional Teams
2006 yes no
2007 yes no

30. Quality Circles
2006 yes no
2007 yes no

31. Work Cells
2006 yes no
2007 yes no

32. Pay for Performance
2006 yes no
2007 yes no

33. Delivery Performance Improvement
2006 yes no
2007 yes no

34. Process Variation Analysis
2006 yes no
2007 yes no

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Section IV

This section provides an opportunity for you to identify other CI activities relevant to your organization.

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Were there any CI activities that your hospital staff worked on in 2006 and/or 2007 that were not included in this survey?

What area of performance do you feel needs to be improved upon in 2009?

In general, what performance areas and or CI activities do you feel are relevant to a hospital setting?

Appendix B

NAME

HOSPITAL

PHONE

Oregon State University
School of Mechanical, Industrial and Manufacturing Engineering
Oregon State University, 204 Rogers hall, Corvallis, Oregon 97331
T 541-737-5641| **F** 541-737-5241

Script and Questions for Follow-up Telephone Interview

Greeting:

"Good morning, my name is John Holliday, and a couple of months ago I asked you to participate in a survey to determine a mathematical model for improving several key characteristics, e.g. costs, errors, and patient satisfaction. Today, I am calling to ask if you would not mind in participating in a relatively short phone interview to answer 6 questions as a follow-up to the survey. It should not take more than 15 minutes, do you have time now, or when would you like to schedule this interview?"

Questions:

1.) Who develops the training schedule and what is the strategy for accomplishing the training?

2.) Please describe the relationship, as you see it, between employees trained in CI tools and techniques and the number and complexity of CI projects undertaken?

3.) Which projects use more tools than other, and can you describe the outcomes when more tools are used rather than fewer tools?

4.) Of the tools used, which tools are used more often, least often and have you noticed tool usage associated with one department or group than another and why?

5.) How did you decide on which tool(s) to use for each project?

6.) Which departments participate in CI activities and projects?

7.) If you had to rank the participation amongst departments, which would rank the highest in number of CI projects undertaken and which would rank the lowest?

Salutation:

"Thank you so much for providing this valuable information. The results of the study will be available within the next few months and a copy of the information pertinent to you hospital will be sent to you. Thank you again from myself and Oregon State University for the generous use of your time. Goodbye."

Appendix C

1. A brief description.

This study will use a survey to determine the impact of continuous improvement (CI) projects on hospitals in Oregon, Washington and Idaho. The survey will be delivered to administrators of public hospitals in Oregon, Washington and Idaho. The data from the survey will be used to inform the participating hospitals administrators of their standing within the group of hospitals surveyed. They will also receive individualized information to aid in future CI projects within their hospital. The results of this study may also be published, based on the findings. The PI for this project is Dr. Doolen. The student experimenter is John Holliday.

2. Background and Significance

This study will investigate the effect of CI projects on public hospitals in Oregon, Washington and Idaho. In this study, "success" will be measured as percent improvement in costs, error reduction, lab results wait times, patient room prep time, patient satisfaction, and employee satisfaction. Participants for this study are administrators from public hospitals in Oregon, Washington and Idaho. The survey instrument used in this study will be administered on-line. The study will help determine whether or not various combinations of employees trained in CI techniques, departments involved in CI project, and mix of CI tools improve hospital success, as measured by performance in costs, error reduction, wait times for lab results, time to ready a room for a new patient, patient satisfaction and employee satisfaction.

3. Methods and Procedures

The survey will be administered to 9 hospital administrators chosen randomly from three strata defined be hospital size, i.e. number or beds (1-99 = small, 100-299 = medium, 300+ = Large). Participation will be voluntary, and participants will receive a summary of their results compared against the results of all participating hospitals. This summary may provide valuable information for the hospitals administrators to use in planning future CI projects.

A three contact system of e-mails will be implemented. The first e-mail will be sent to each administrator and will contain a copy of instructions/informed consent document, which will also contain a link to access the on-line survey. The e-mail will also contain the instructions necessary for the administrator to access the on-line survey. The instructions/informed consent document informs the administrator about the survey as well as their rights as a participant. No signatures will be collected on the informed consent. The administrator will be permitted to ask questions (through e-mail or by phone) prior to making a decision on whether to complete the survey. The administrator will complete the survey, which is estimated to require 15-30 minutes of time

A second thank you e-mail will follow the first e-mail in four to five days to express appreciation for responding and requesting the administrator to complete the survey soon if the survey has not been completed.

In two weeks the third and final e-mail will be sent to those that have not completed the survey encouraging them to complete the survey and reminding them of the advantages to complete the survey.

The survey program will randomly assign a code to each hospital. There will be linkage between an individual hospital survey response and the hospital ID. If this study is published no linkage to specific hospital results will be released.

As the second part of this study, a telephone contact survey question will be implemented. There will be an e-mail prior to telephone contact and follow the same format as the first e-mail of part 1, with one exception and that is the instructions will contain information regarding the phone survey, time, date, and suggestion for alternative time and date if the one selected is inconvenient. No signatures will be collected on the informed consent. The administrator will be permitted to ask questions (through e-mail or by phone) prior to making a decision on whether to complete the survey. The administrator will complete the survey, which is estimated to require 15 minutes of time.

A second thank you e-mail will follow the first e-mail in four to five days to express appreciation for responding.

4. Risks/Benefit Assessment

We do not believe there are any discernible risks to the participants in this research. Participation in the survey is voluntary. There is a need for identifying individual administrator's responses, and this information will be only known to the PI and student experimenter. Administrators may choose not to participate. Only participants will receive the summary of the study.

We do believe there are direct benefits to administrators participating in this survey. We hope that by understanding the impact of direct and individualized feedback for future CI projects, administrators choose to participate.

5. Participant Population

All administrators of public hospitals in Oregon, Washington and Idaho will be given the opportunity to complete the survey. The total population is the 210 administrators/public hospitals in Oregon, Washington and Idaho. The subject population is restricted only to administrators of public hospitals in Oregon Washington and Idaho.

6. Subject Identification and Recruitment

An e-mail will be sent to each administrator of a public hospital in Oregon, Washington and Idaho. The e-mail will contain a copy of instructions/informed consent document. This document contains the instructions necessary for the administrator to access the on-line survey. The instructions/informed consent document informs the administrator about the survey as well as their rights as a participant. No signatures will be collected on the informed consent.

7. Compensation

There is no compensation for any administrator participating in the survey.

8. Informed consent process

All administrators will receive an e-mail attachment with a copy of the instructions/informed consent document, which can be printed at their site. As part of these instructions, all elements of informed consent will be explained. No signature will be collected on the informed consent. If signatures were required on the informed consent document we would then have the names of the administrators that have chosen to participate. We wish to have the survey be anonymous, so do not want to have any signatures that would identify participants. We are requesting the IRB to waive the requirement for a signed informed consent, according to the criteria described in 45 CFR 46.117 (c), part 1 and part 2. We believe that this research presents only minimal risk and does not harm the subjects in any way. In addition, if administrators are required to sign the informed consent they may feel that they are no longer anonymous.

8. Anonymity or confidentiality

The survey does require that individuals provide data for their hospital which links a hospital to a particular survey. This information is only known to the PI and the student experimenter and is needed to provide the individualized feedback to each administrator.

9. Attachments.

The survey instruction sheet/informed consent document is attached.

The survey is attached.

The e-mail templates that will be used to communicate with administrators are attached.

Attachments:

First e-mail Template:

School of Mechanical, Industrial and Manufacturing Engineering

Oregon State University, 204 Rogers hall, Corvallis, Oregon 97331
T 541-737-5641| **F** 541-737-5241

Date: (*current date*)

Dear Mr./Ms. (*Administrator name*):

As a hospital administrator, your help is needed in assessing how continuous improvement (CI) activities have contributed to your hospital's performance. A survey has been developed to determine if factors, such as the percentage of employees trained in CI techniques, the number of departments involved, and/or the specific tools used impact results.

Attached to this e-mail is a letter outlining what to expect in completing the survey and outlining your rights if you choose to participate in the study. To make it easy to complete the survey, a web site has been created. To participate in this study, go to the following link: *[http://www.xxxx.xxx]*. To complete the survey, log in using the following unique identifier *[unique identifier code]*.

Feedback will be sent to each participating hospital. A report comparing your hospital's individual results to the entire set of participating hospitals will also be provided. These results may be helpful to your organization in planning future CI activities. Thank you in advance for considering this opportunity to participate in this important study.

Kind Regards,

John Holliday, PhD Candidate
School of Mechanical, Industrial, and Manufacturing Engineering
Oregon State University

Second E-mail:

School of Mechanical, Industrial and Manufacturing Engineering

Oregon State University, 204 Rogers hall, Corvallis, Oregon 97331
T 541-737-5641| **F** 541-737-5241

Date: (*current date*)

Dear Mr./Ms. (*Administrator name*):

Last week an e-mail along with an attachment was sent to you requesting your participation in a study of continuous improvement projects in hospitals.

If someone at your hospital has already completed the online survey please accept our sincere thanks. If you have not yet had an opportunity to complete the survey, we would like to request your assistance. This study will be very helpful to identifying those factors that help hospitals get the most out of their continuous improvement activities. Your participation will help in this effort.

If you need the link to the study website or your unique identifier code, please respond to this e-mail and this information will be sent to you directly. Thank you for your assistance.

Sincerely,

John Holliday, PhD Candidate
School of Mechanical, Industrial, and Manufacturing Engineering
Oregon State University

Third and final e-mail Template:

Oregon State University

School of Mechanical, Industrial and Manufacturing Engineering

Oregon State University, 204 Rogers hall, Corvallis, Oregon 97331
T 541-737-5641| **F** 541-737-5241

Date: (*current date*)

Dear Mr./Ms. (*Administrator name*):

In early January we sent an e-mail requesting your participation in an important study of continuous improvement projects in hospitals. We are writing again because of the importance of your hospitals' information. It is only by hearing from a large number of hospitals that we can be sure that the study results are accurate.

The survey should take only 30 minutes to complete. If you have any questions about the survey, need the link to the study website, or need your unique identifier code, please respond to this e-mail and this information will be sent to you directly. .

Thank you for your assistance in this important research.

Sincerely.

John Holliday, PhD Candidate
School of Mechanical, Industrial, and Manufacturing Engineering
Oregon State University

Appendix D

HOSPITAL NAME
Adventist Medical Center
Ashland Community Hospital
Bay Area Hospital
Blue Mountain Hospital
Cottage Grove Community Hosp
Doernbecher Children's Hospital
Grande Ronde Hospital
Harney District Hospital
Kaiser Sunnyside Medical Center
Lake District Hospital
Legacy Emanuel Children's Hosp
Legacy Emmanuel Hospital
Legacy Good Samaritan Hospital
Legacy Meridian Park Hospital
Legacy Mount Hood Medical Ctr
Lower Umpqua Hospital
McKenzie Willamette Hospital
Mercy Medical Center
Mountain View Hospital District
Oregon State Hospital
Pioneer Memorial Hospital
Providence Milwaukie Hospital
Providence Portland Medical Ctr
Providence St Vincent Med Ctr
Rehab Institute Of Oregon
Rogue Valley Medical Center
Sacred Heart Medical Center
Salem Hospital
Salem Hospital Regional Rehab
Samaritan Albany General Hosp
Samaritan Lebanon Comm Hosp
Samaritan North Lincoln Hosp

Samaritan Pacific Communities
Santiam Memorial Hospital
Serenity Lane Treatment Center
Shriners Hospital For Children
Sky Lakes Medical Center
St Anthony Hospital
St Charles Med Ctr-Redmond
St Charles Medical Ctr-Bend
Tillamook County General Hosp
Tuality Forest Grove Hospital
VA Medical Center-Portland
VA Southern Oregon Rehab Ctr
Wallowa Memorial Hospital
West Valley Hospital
Willamette Valley Medical Ctr
Beacon Hospital & Rehab
Bear Lake Memorial Hospital
Bingham Memorial Hospital
Bonner General Hospital
Boundary Community Hospital
Caribou Memorial Hospital
Cascade Medical Center
Clearwater Valley Hospital
Eastern Idaho Regional Med Ctr
Elmore Medical Center
Franklin County Medical Center
Harms Memorial Hospital
Idaho Elks Rehabilitation Hosp
Idaho State School & Hospital
Kootenai Behavorial Health Ctr
Lost Rivers Medical Center
McCall Memorial Hospital
Minidoka Memorial Hospital
Oneida Hospital
Saint Alphonsus Reg Med Ctr
Shoshone Medical Center

St Joseph Regional Medical Ctr
St Luke's Magic Valley Med Ctr
St Luke's Regional Medical Ctr
St Luke's Wood River Med Ctr
St Mary's Hospital
State Hospital South
Teton Valley Hospital
VA Medical Center-Boise
Walker Center
Weiser Memorial Hospital
Allenmore Hospital
Auburn Regional Medical Center
Capital Medical Center
Cascade Medical Center
Cascade Valley Hospital
Columbia Basin Hospital
Coulee Community Hospital
Dayton General Hospital
Deaconess Medical Ctr-Spokane
East Adams Rural Hospital
Enumclaw Regional Hospital
Evergreen Hospital Medical Ctr
Garfield County Hospital
Good Samaritan Hospital
Grays Harbor Community Hospital
Harborview Medical Center
Harrison Medical Center
Highline Specialty Center
Island Hospital
Jefferson Healthcare
Kadlec Medical Center
Kennewick General Hospital
Kindred Hospital Seattle
Kitsap Mental Health Center
Kittitas Valley Community Hosp
Klickitat Valley Health

Lake Chelan Community Hospital
Legacy Salmon Creek Hospital
Lincoln Hospital
Madigan Army Medical Center
Mark Reed Hospital
Mary Bridge Children's Hospital
Mason General Hospital
Mid-Valley Hospital
Morton General Hospital
Mount Carmel Hospital
Newport Community Hospital
North Valley Hospital
Northwest Hospital
Ocean Beach Hospital
Odessa Memorial Hospital
Okanogan-Douglas District Hosp
Olympic Medical Center Hospital
Overlake Hospital Medical Ctr
Pierce County Human Services
Prosser Memorial Hospital
Providence Everett Medical Ctr
Providence St Peter Hospital
Pullman Regional Hospital
Quincy Valley Medical Center
Regional Respiratory Hospital
Samaritan Healthcare
Scarlet Yocum Memorial Hospital
Schick Shadel Hospital
Seattle Children's Hospital
Skagit Valley Hospital
Skyline Hospital
Southwest Washington Med Center
St Clare Hospital
St Francis Hospital

Stevens Hospital
United General Hospital
University Washington Med Ctr
VA Puget Sound Health Care Sys
Valley General Hospital
Valley Hospital Medical Center
Valley Medical Center
Virginia Mason Medical Center
Washington State Penitentiary
Wenatchee Valley Medical Center
West Seattle Psychiatric Hosp
Western State Hospital
Whidbey General Hospital
Whitman Hospital & Medical Ctr
Willapa Harbor Hospital
Yakima Regional Medical Center
Canyon View Hospital
Cassia Regional Medical Center
Gritman Medical Center
Idaho Falls Recovery Center
Madison Memorial Hospital
St Benedict's Family Med Ctr
State Hospital North
Treasure Valley Hospital
Walter Knox Memorial Hospital
Blue Mountain Recovery Center
Columbia Memorial Hospital
Holy Rosary Medical Center
Mid Columbia Medical Center
Pioneer Memorial Hospital
Roseburg VA Medical Center
Silverton Hospital
Three Rivers Community Hospital

Central Washington Hospital
Group Health Central Hospital
Holy Family Hospital
Memorial Health Center
Naval Hospital
Naval Hospital
Othello Community Hospital
Shriners Hospital For Children
Spokane VA Medical Center
St Luke's Rehabilitation Inst
Walla Walla General Hospital
Yakima Valley Memorial Hospital
Gooding County Memorial Hosp
Intermountain Hospital Of Boise
Portneuf Medical Center East
Steele Memorial Medical Center
Lakeside Milam Recovery Center
Providence Centralia Hospital
Providence Everett Medical Ctr
Sacred Heart Medical Center
St Mary Medical Center
Sunnyside Community Hospital
Swedish Hospital Ballard Campus
Swedish Medical Center
Swedish Medical Ctr Providence
Toppenish Community Hospital
Fairfax Hospital
Lourdes Medical Center
Tri-State Memorial Hospital
Coquille Valley Hospital
Curry General Hospital
Providence Medford Medical Ctr
Providence Seaside Hospital
Rogue Valley Medical Center

Willamette Falls Hospital
West Valley Medical Center
St John Medical Center
St Joseph Hospital
St Joseph Medical Center
St Joseph's Hospital
St Peter Chemical Dependency