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Lean and Six Sigma Impact on Operating Room Safety Attitudes and Efficiency

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by

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Abstract

Non-healthcare organizations have utilized Lean Six Sigma methodologies for several decades to eliminate waste, decrease expenses, and improve efficiency. This approach to problem-solving can be successfully applied to health care process improvement projects. Health care leaders and front line staff can use a prescribed set of steps to define steps in care processes and identify potential solutions. Health care leaders can use Lean Six Sigma tools such a fishbone diagram or a cause and effect matrix to identify issues. After carefully organizing the problems into groups according to priority, leaders can develop action steps toward resolution.

Keywords: Six Sigma, Lean, healthcare process improvement, process redesign, operating room efficiency, parallel processing, safety attitudes, and measuring safety attitudes.

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CHAPTER I

Introduction

As the competition in health care intensifies, organizations must look for ways to improve their operational efficiency. The ability to address customer demands for high quality, safe health care services is directly influenced by an organization's success in eliminating waste and streamlining processes. Operating rooms represent one of the biggest revenue streams for many hospitals. A study at the University of Pittsburgh Presbyterian and Montefiore Surgery Department states that surgery departments in the United States account for up to 60% of total hospital revenue (Garner, 2012). The ability to increase efficiency hinges on how well an organization can move the patient through the surgical process and complete other non-clinical turnover tasks such as room cleaning and set-up. Research has shown that the elimination of wasted steps and the ability to perform some tasks in parallel to others can significantly improve the operating room's efficiency (Friedman, Sokal, Chang, & Berger, 2006).

Discussions about improving efficiency and eliminating waste must go in tandem with the assurance that patient safety and the prevention of errors remain a high priority. Process improvement activities often focus on reducing turnover or turnaround time. However, room turnover time is just one of the metrics that contribute to a profitable and safe operating room. It is important to remember that in any process improvement activity, the potential exists for unsafe practices to emerge leading to reduced patient care quality and safety. Infection control practices in particular must be strictly followed to ensure that potential gains in efficiency are not offset by lapses in proper cleaning and disinfecting practices ("Fast Turnover," 2012).

Problem Statement

Declining reimbursements in healthcare due in part to Medicare rule changes have created an environment where hospitals must work smarter, not harder. Initiatives that target cost savings and the elimination of wasted time in the operating room have become more popular. Hospitals must look for ways to improve efficiency in the operating room while at the same time maintaining patient safety. Improvements in clinical and non-clinical processes in the operating room make way for increased capacity and a reduction in wasted time and resources.

Implementing improvements that increase patient flow through the surgical experience can be both a challenge and an opportunity for success. The application of Lean and Six Sigma business management methods can assist hospital surgical departments to identify time wasters and redundant practices, streamline processes, and ultimately increase capacity. These techniques have been in use in general manufacturing and other non-healthcare industries for more than 50 years. Applicability to the healthcare arena is relatively new. Research is now emerging that demonstrates the value of these techniques in healthcare, including the operating suite. By identifying a problem and implementing lasting improvements, the use of Lean and Six Sigma have demonstrated their effectiveness in achieving sustainable goals (Fairbanks, 2007).

Justification of the Project

The need for improved efficiency in health care has never been more important than it is today. As the country's largest industry (United States Department of Labor Bureau of Labor Statistics [BLS], 2013), health care is poised for continued growth as individuals in the Baby Boomer generation near their seventies. The health care and social assistance occupations are expected to add the largest number of jobs by the year 2022 according to the Bureau of Labor Statistics (BLS, 2013). The recent recession did not have as great an impact on this employment sector as it did others and, in fact, healthcare jobs continued to grow even during that period. This resilience will continue to create employment growth along with better access to care created by the Affordable Health Care Act. External influences, such as the current economic climate, declining reimbursement rates, and an aging population that is consuming more services, are creating new challenges for hospitals. Surgical departments faced with increasing volumes for the aforementioned reasons, must think creatively to survive. The operating room must deliver care in an even more patient-focused and efficient manner.

Advancing technologies in perioperative care have made surgery possible in patients who may not have been candidates 15-20 years ago. The use of laparoscopic, endoscopic, and arthroscopic surgery has greatly increased the volume of surgical cases for many hospitals. While the increased volume is a welcome occurrence for many hospitals, it does not come without the addition of staff, facilities, and technology in many cases. However, adding staff, space, and equipment does not always translate into efficient operations and high quality patient care.

Some of the increased volumes in surgeries are related to total joint replacements, with total knee replacements (TKR) outpacing total hip replacements (THR). From 1993-2009, the number of THRs nearly doubled, while the number of TKRs for the same time period nearly tripled. According to the American Academy of Orthopaedic Surgeons (AAOS), much of this increase seen especially in younger adults is attributed to the growing epidemic of obesity in the United States. According to a study conducted at the Hospital for Special Surgery in New York, NY, the volume of TKRs outpaced the number of THRs in patients with body mass indexes of greater than 25gm/m^2 (American Academy of Orthopedic Surgeons [AAOS], 2014). In 1993, surgeons performed 1.06 TKRs for every THR and in 2009 the number had grown to 1.6 TKRs for every THR (AAOS, 2014). From 1993-2009, the number of patients having a TKR in the age group 18-64 increased 56% compared with an increase of 35% for this same time frame and demographic undergoing a THR (AAOS, 2014).

Any hospital that currently performs total joint replacements is already feeling the impact of this dramatic increase in total joint replacements. Surgical departments have had to look for ways to streamline operations on both the clinical and non-clinical sides of the equation. The challenge to maintain the latest technology, available surgical suites, and qualified staff puts even more pressure on surgical departments to perform at the peak of efficiency. As volumes of surgeries increase, most hospitals and health care organizations have implemented surgical metrics that are consistent with safe, quality, and efficient care of the patient. These metrics include such activities as first case on-time starts, operating room utilization, block scheduling utilization, turnover time by surgeon, and turnover time of the room. Hospitals attempt to meet or exceed these metrics in the benchmarking process that takes place nationally, locally, and corporately.

As was common in non-health care related industries beginning in the 1980s, health care organizations are now using the same tools that have helped improve manufacturing throughput and efficiency. Six Sigma and Lean business management tools have emerged as methods of improving healthcare efficiency and eliminating wasted resources such as time, motion, and processes.

Purpose

The purpose of this capstone project was to improve operating room efficiency while maintaining safe, quality patient care. This was done using Six Sigma and Lean business management tools. As discussions about improved processing time and patient throughput took place, there was widespread interest in the impact on patient safety as perceived by the healthcare team. The project administrator collected data on staff attitudes of safety before and after the implementation of Lean and Six Sigma using the Safety Attitudes Questionnaire Short Form from the University of Texas (Sexton et al., 2006). The questionnaire was administered to the surgeons and operating room staff and measured caregiver attitudes about six patient safety domains. The domains are Teamwork Climate, Safety Climate, Perceptions of Management, Job Satisfaction, Working Conditions, and Stress Recognition. Preliminary conversations held with the operating room director and chief nursing officer of the facility for planning purposes revealed that staff attitudes of these domains are slightly negative. The staff has expressed that they sometimes feel pushed to choose between safety and efficiency while striving to meet the benchmarks set by corporate leadership.

Project Question

The capstone project question was “Do Lean and Six Sigma methodologies have an impact on the perceived safety attitudes of the staff and efficiency of the operating room?” The PICOTS format (Sackett, Strauss, Richardson, Rosenberg, & Haynes, 2000) was used to further define the question.

- Population (P): staff (surgeons, nurses, technicians) of an operating room in a community hospital.
- Intervention/Issue (I): implementation of Lean and Six Sigma activities to improve operating room efficiency and use of the Safety Attitudes Questionnaire to assess staff perceptions of safety in the OR.
- Comparison (C) intervention: pre-intervention metrics for turnover time and staff attitudes of safety in the operating room.
- Outcomes (O): post-intervention metrics for operating room turnover time and staff attitudes of safety in the operating room.
- Timing (T): length of time needed to implement Lean and Six Sigma process improvement activities.
- Setting (S): perioperative suite in a community hospital in the piedmont region of North Carolina.

Definitions of Terms

- Lean: "a never-ending, systematic approach for identifying and eliminating waste, improving flow of a process while engaging employees" (Sperl, Ptacek, & Trewn, 2013, p. xii). Lean's focus is customer-driven; the customer defines the value and the amount they are willing to pay for a product or service.
- Process redesign: healthcare process redesign can be broadly defined as using best practices to achieve efficient and effective care for a patient while identifying delays, unnecessary steps, or potential for error in the process.

- Operating Room Efficiency: the orderly and systematic flow of processes within the operating room. Measured by metrics for key processes such as first case starts, room turnover time, non-clinical processing time etc.
- Room Turnover: a measure of operating room efficiency. "The number of minutes that occur between the previous patient exiting the room (wheels out) to the current patient entering the room (wheels in) in a particular room, regardless of the surgeon" (Community Health Systems [CHS], 2014, p. 27)
- Safety Culture: "the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management" (Sexton et al., 2006, p. 2)
- Six Sigma: a statistical term that measures how much of the normal process variation falls with the process requirements. As a business tool, "Six Sigma is a structured, quantitative, five phase approach to continuous improvement and problem solving" (Sperl et al., 2013, p. xiii)

Summary

A major problem in many operating rooms is excessive turnover time between cases. Decreased turnover time can reduce staff overtime and improve surgeon satisfaction. In addition to room turnover time, there are several contributing processes that must be considered in order to reduce waste and repetitive actions. Lean and Six Sigma methodologies have emerged from the manufacturing community to an ever-increasing positon of prominence in health care settings. Of critical importance is the notion that while efficiency in the operating room can be improved through process changes, no amount of efficiency can serve as a substitute for safe patient care.

CHAPTER II

Research Based Evidence

Manufacturing organizations have used Lean and Six Sigma business management tools for several decades to streamline processes, eliminate waste, and reduce expenditures. A research team at Massachusetts Institute of Technology International Motor Vehicle Program coined the phrase "Lean" in the late 1980s ("What is Lean," 2014). The lead project administrator, Dr. James Womack, used the term to describe Toyota's business processes. The core premise of Lean is to maximize value for the customer while reducing waste and using fewer resources. Lean management principles improve workflow by reducing unnecessary delays, workarounds, and the process of rework, which is performing a task or service again because of an error or omission.

Six Sigma was developed by the Motorola Company in Schaumburg, IL in 1986. Statisticians use the term *sigma* (σ) from the Greek alphabet to denote the variability of a process by measuring the number of standard deviations from the mean. A process with Six Sigma reliability means that there are no more than 3.4 defects per million opportunities for process variation (DPMO). The pursuit of excellence through a reduction in errors is one of the underlying tenants of the Six Sigma methodologies.

Review of Literature

A literature review was conducted using a variety of databases and search engines. These databases included the Cumulative Index to Nursing and Allied Health Literature (CINAHL), ProQuest, EBSCO, and the search engine Google. Key words and phrases used were Six Sigma, Lean, healthcare process improvement, process redesign, operating room efficiency, parallel processing, safety attitudes, and measuring safety attitudes.

A review of the literature demonstrates that there is a rapidly growing interest in healthcare process improvement. Multiple methods for healthcare performance improvement have been described dating back to the 1990s. Safety attitudes assessment in the healthcare literature as it relates to process improvement initiatives has emerged in the past nine to ten years.

Conceptual Literature Review

Healthcare Process Improvement

The current healthcare process improvement environment is the result of a century long effort that began with the acknowledgement of the role of quality in healthcare. It has evolved into a system that monitors, quantifies, and incentivizes process improvement. The roots of the healthcare quality movement trace back to the 19th century when Semmelweis stressed the importance of hand washing in medical settings. It continued with Florence Nightingale’s discovery of the association between poor living conditions and the high mortality rate of soldiers (Marjoua & Bozic, 2012). A gifted surgeon from the Massachusetts General Hospital, Ernest Codman, led the creation of hospital standards to assess the outcomes of health care. He founded the American College of Surgeons and its Hospital Standardization Program. That organization eventually became The Joint Commission ("The Joint Commission," 2014).

Another legend in healthcare process improvement is Quint Studer. He has lectured and written extensively on the subject. He is the founder of the Studer Group. A recipient of the 2010 Malcolm Baldrige National Quality Award, the Studer Group implements evidence-based leadership systems to help organizations accelerate and sustain performance improvement. Studer has been in the healthcare field for over 29 years and shares his knowledge with thousands of healthcare leaders each month through national speaking engagements. In an article published in June 2014, he states that in order for organizations to sustain goals, they must do three things:

- Ensure that staff know why process improvement is needed
- Hold leaders accountable to champion the process and tie it to performance outcomes
- Give employees and leaders the tools they need to sustain the gains (Studer, 2014).

In 1966, Dr. Avedis Donabedian, a physician and pioneer in the study of healthcare quality published his work using the elements of structure, process, and outcomes to evaluate medical outcomes. This publication described methods for evaluating medical quality. It was less about outcomes and more about the methods of evaluating care. Several key studies are included in this work and they each involved the creation of a definition for quality.

Bearing in mind that the work of Donabedian was published in 1966, some of the studies he described address issues that are still seen today albeit in a slightly different format. A study by Lembcke, which was published in 1956, was deemed by Donabedian to be “perhaps the single best paper that describes the underlying concepts as well as the methods of the highly structured approach developed by Lembcke to audit hospital records” (Donabedian, 1966, p. 722). Discussion about Lembcke’s medical record audits as a measure of quality was included in this work. Within that context, Donabedian questioned whether an audit of the medical record was a measure of patient care quality or the quality of the record. In the era of electronic medical records, documentation of patient care activities continues to be used to measure quality and compliance with regulations for health care. Ultimately, this compilation of studies by Donabedian posited that care processes and care structures had a contributory role in care outcomes (Donabedian, 1966).

After the introduction of Donabedian's work, there was an effort to transition to a model that measured healthcare quality that was data driven. The Quality Improvement Initiative that was proposed by the Health Care Financing Administration in 1992 was the first time algorithms based on clinical guidelines and information from claims history were used to create evidence-based healthcare quality improvement (Marjoua & Bozic, 2012).

From 1995-2000, several papers concerning healthcare quality were published including the sentinel report by the Institute of Medicine (IOM), "To Err is Human" (Institute of Medicine, 2000). This report on the state of medical care in the United States was an alarm to healthcare organizations throughout the country. The report stated that between 44,000 and 98,000 patients died in hospitals from preventable medical errors. The costs of these errors were estimated to be between 17 and 29 billion dollars a year (Institute of Medicine, 2000). Quality improvement initiatives became widespread in healthcare and work began to emerge that included the use of safety tools previously only used in the aviation industry.

In 2003, several years along on the healthcare quality spectrum, the Centers for Medicare and Medicaid Services (CMS) and the Centers for Disease Control and

Prevention (CDC) introduced the Surgical Care Improvement Program (SCIP). SCIP is a set of process and outcome measures for cardiac, infection, deep vein thrombosis, respiratory, global, and vascular surgery outcomes. Today, the SCIP is coordinated by 10 healthcare regulatory agencies who serve through a Steering Committee platform. Today, hospitals receive reimbursement based upon their SCIP measures among other metrics.

Studies from the mid-2000s in healthcare process improvement often included the work of William Edwards Deming, an engineer, statistician, professor, author, and a man referred to as the "Father of the Third Phase of the Industrial Revolution" (The Deming Institute, 2015). Deming developed the popular Plan, Do, Study, Act (PDSA) methodology often used in healthcare process improvement. In a study conducted in 1998, the PDSA cycle was used to improve cardiac operating room (OR) turnaround time (Hall, Moravick, & Affisco, 2008).

The study evaluated the use of OR time for the ,1200 cardiac surgeries performed at a large, tertiary hospital. The variable cost of OR time was determined to be $4000 an hour after a fixed startup cost of $18,000. Two surgeries were typically done in each of seven ORs daily. Turnaround time (TT) was defined as when the first patient leaves the OR and when the next patient enters the OR. Room cleaning and new case set-up were included in this calculation. Time to incision (TI) began when the next patient entered the room until the surgeon made the incision. Room cleaning time was defined as the time used by the Environmental Services Team to clean the room between patients. The definition of total turnaround time (TTT) used was the sum of the turnaround time (TT) and the time to incision (TI). This effectively represented the amount of time the physician was waiting to begin their case. The time periods that were studied were turnaround time, room cleaning time, and time to incision. The study, which included 79 cardiac cases, was conducted during the months of May, June, and July 2006. Once data was collected on these parameters, benchmarking of the data to published national norms took place. Discovering that the ORs were experiencing serious turnaround issues, the project administrators applied the PDSA process. Using this process, the project administrators implemented a parallel processing system whereby perioperative clinical and non-clinical activities are done simultaneously rather than sequentially. The results showed that total turnaround time (TTT) using parallel processing decreased from 139.99 to 79.6 minutes (42.6%). The estimates of savings of this improvement were stated to be 1.28 million dollars a year.

Process redesign. Process redesign in the operating room is one way to improve efficiency for activities such as turnaround time, room cleaning time, and time to incision. In a study published in 2006, project administrators sought to reduce non-operative time (NOT), defined as the time between the end of case to the time when skin prep begins for the next patient (Harders, Malangoni, Wright, & Sidhu, 2006). A prospective study to reduce non-operative time was conducted in two of the 17 ORs in a tertiary care academic medical center.

The study focused on decreasing non-operative activities in the OR in order to minimize nonclinical disruptions. Cases with duration of less than two hours were selected for the study. A target NOT was established at 35 minutes and cases with a similar timeframe in other ORs served as the control group in the study. Over a three month period, there was a significant reduction in NOT (42.2 versus 65 minutes), turnaround time (26.4 versus 42.8 minutes), and anesthesia related time (16.9 versus 21.9 minutes). The reductions were a result of a conscious effort to reduce nonclinical interruptions and minimize non-operative tasks in the OR. The implementation of parallel processing, process reengineering, and process redesign contributed to the reduction of NOT. These results demonstrated that a significant reduction in NOT can be seen when a multidisciplinary process redesign approach is employed (Harders et al., 2006). This study is significant to the project administrator's capstone project because it addresses common causes of delays in OR turnaround time.

A study published in the Journal of the American College of Surgeons in 2011 reviewed the work done by a multidisciplinary surgical process improvement team at the Mayo Clinic (Cima et al., 2011). Value stream maps were constructed of the perioperative processes. Each process step was categorized according to three domains; personnel, information processed, and time. Multidisciplinary teams worked to increase value at each of five work streams; minimizing volume variation, streamlining preoperative processes, reducing non-operative time, eliminating redundant information, and encouraging employee engagement. Processes were redesigned through these activities.

The process redesigns were implemented in surgical specialties and key performance metrics were collected before and after implementation. The results demonstrated that process redesign resulted in substantial improvements in on-time starts and a reduction in number of cases starting or continuing past 5 p.m. Significant improvements were achieved in non-operative time, staff overtime, and ORs saved.

These changes resulted in substantial increases in financial performance and OR efficiency (Cima et al., 2011).

Operating Room Efficiency

Operating room efficiency is a trademark for physician and nurse satisfaction. A study by the leadership team of a large New York City area hospital in 2008 focused on enhancing communication among personnel from anesthesia, the surgery team, and registered nurses. Another goal was to identify areas for improved efficiency. Through a group retreat process, several areas were identified for potential process improvement: on-time surgical starts, patient transfers to the OR, turnaround time, accuracy of surgeon preference cards, consistency of staff performance, and multidisciplinary communication about patient care needs (Scheriff, Gunderson, & Intelisano, 2008).

Key operating efficiencies that enhance patient safety were part of this initiative. One process that was implemented in this program included a system whereby the surgeon, the scrub tech, and the circulating RN performed a specimen “time out” to improve specimen handling accuracy. The same type of process was developed for medications. During the surgical time out process, all medications to be placed on the sterile field were reviewed by all members of the perioperative team. A computerized medication calculator was implemented, which allowed staff to pick a commonly used medication from the formulary, enter the patient’s weight and the maximum allowable dose of the medication was calculated. This ensured that the proper dosage of medication was available on the sterile field with minimal disruption to the procedure (Scheriff et al., 2008). Operating room efficiency is a critical concept to this project as it represents the cumulative impact of the associated process redesign activities.

Parallel Processing

Parallel processing is the practice of performing the clinical and non-clinical activities associated with a surgical procedure in tandem throughout the OR suite, rather than the historical methods whereby activities were performed sequentially. In the past, the patient was held in the preoperative area while the room was cleaned and restocked. The patient was then brought to the OR to receive intravenous medications, be shaved by the surgeon if necessary, and receive regional anesthesia. Prior to the start of parallel processing workflows, all of these activities occurred sequentially with little variation. The study believed to be the first involving parallel processing, was performed in 2005 by Friedman and others (Friedman et al., 2006). The team of project administrators created a study to compare the OR efficiency of hernia repair patients who were part of a parallel processing workflow with patients having hernia repairs who were treated in a traditional, sequential processing workflow. The team eliminated potential interpersonal variability by involving a single surgeon. The project administrators identified three specific time intervals for the study: initiating intravenous anesthesia, injecting local anesthesia as a perioperative block, and applying skin cleaners and drapes (sedate, block, and prep).

Activities performed as part of the parallel processing workflow were the concomitant prepping of the patient in the holding area while the room was being cleaned and restocked and initiation of the intravenous medication prior to the patient being transported to the OR. The baseline measurements used prior to the implementation of the parallel processing were gathered from a historical group. This group was comprised of 55 patients experiencing the sequential processing method. The means of the times for sedate, block, and prep were 19.6 +/- 5.3 minutes, 23.9 +/- 6.8 minutes for the operative time, and 32.6 +/- 30 minutes for the room turnover time. The 17 patients in the study labeled the concurrent control group experienced sequential processing as well for their cases. The concurrent control group had a sedate, block, and prep mean time of 17.3 +/- 7.8 minutes, a mean operative time of 23 +/-9.2 minutes, and a mean room turnover time of 24 +/-0 minutes. This represented no statistically significant difference between the times of the historical and concurrent control groups. The study group (n=66), using parallel processing, had a sedate, block, and prep times of 7.7 +/- 3.1 minutes, an operative mean time of 25.2 +/-9.5 minutes, and a room turnover mean time of 17.8 +/- 10.8 minutes. Within the study group, there was a statistically significant difference from the concurrent control group and the historical group for both the sedate, prep, and block times, and the room turnover times. Operative times did not experience any statistically significant differences as they were adjusted to account for various hernia surgery types. There were no differences in operative methods as one would expect while observing a single surgeon. There were no downstream delays created as a result of the parallel processing activities. There was at least a 33% reduction in the operative surgeon's OR time each day compared to the concurrent control group (Friedman et al., 2006) . In this study, moving to a parallel processing workflow created increased capacity for more cases. This study is important to the capstone project as it illustrates a multitude of opportunities to perform key tasks in tandem rather than sequentially.

Safety Attitudes

Errors in the operating room can have catastrophic consequences. In order to ensure safe patient care, it is important to understand the safety attitudes, communications, and teamwork behaviors of the staff. The overwhelming majority of wrong site surgeries and other adverse events in the OR are caused by poor communication according to a report published by The Joint Commission and the Institute of Medicine. The report states that communication errors account for up to 60% of operating room errors. In the Institute of Medicine report from 1999, "To Err is Human", the recommendation to hospitals was to promote effective team functioning as a foundational principle for creating safe hospital systems (Makary et al., 2006). In the Operating Room, the staff may feel pushed to improve efficiency at the expense of patient safety.

In a study to measure teamwork by operating room physicians and nurses by Makary et al.(2006), 60 hospitals were surveyed using the Safety Attitudes Questionnaire Short Form (SAQ Short Form) (Sexton et al., 2006). A total of 2,769 surveys were distributed and 2,135 were completed (222 surgeons, 1,058 OR nurses, 564 surgical technicians, 170 anesthesiologists, and 121 CRNAs), for an overall response rate of 77.1%. The study demonstrated considerable differences in the perceptions of teamwork in the OR. The study validated the SAQ Short Form as a method to measure teamwork, identify disconnects between staff, and evaluate methods aimed at improving patient safety (Makary et al., 2006).

Safety attitudes measurement. Vincent and associates described several elements that influenced the safety environment of a healthcare organization. Those included work environment factors such as staffing levels, managerial support, teamwork, and attitudes of the staff such as overconfidence (Vincent, Taylor-Adams, & Stanhope, 1998). Safety attitudes are one element of a safety culture. Organizations such as The Joint Commission and the United Kingdom National Health Service encourage the measurement of safety attitudes and culture as is seen in industries such as nuclear energy, aviation, and NASA (Sexton et al., 2006).

The ability to measure safety attitudes in healthcare depends on the availability of a tool with adequate psychometric properties. The Safety Attitudes Questionnaire Short Form (SAQ Short Form) was developed from the Intensive Care Unit Management Attitudes Questionnaire (ICUMAQ) (Thomas, Sexton, & Helmreich, 2003). The ICUMAQ was derived from a questionnaire that is widely used in the aviation industry. According to Helmreich, Merritt, Sherman, Gregorich, and Wiener (as cited in Sexton, et.al, 2006), the Flight Management Attitudes Questionnaire (FMAQ) was created when project administrators identified that the majority of aviation incidents happened as a result of breakdowns in crew interactions in the areas of leadership, collaboration, teamwork, speaking up, and communication.

The SAQ Short Form was developed by a group of project administrators at the University of Texas. The validation of the instrument involved the testing of nearly 11,000 clinical areas across intensive care units, operating rooms, inpatient areas, and ambulatory clinics. The study they performed to validate the instrument resulted in a six factor model for Teamwork Climate, Safety Climate, Perceptions of Management, Job Satisfaction, Working Conditions, and Stress Recognition. Benchmarks were established to allow comparisons among organizations. The SAQ is the instrument that will be used to assess safety attitudes among OR staff.

Theoretical Literature Review

Lean

Lean production is a management philosophy whereby customer expectations are addressed with the goal of limiting resources and creating increased value. Lean's focus is on increased efficiency and decreased waste in resource utilization. The Lean methodology was developed by the Toyota Corporation and has been in use in general manufacturing for many years. Hospitals employing Lean have seen increased productivity, reduced costs, improved quality, better teamwork among staff and enhanced revenue. In a Lean organization or division within an organization, everyone is responsible for using Lean thinking and tools in their daily work. Lean defines eight wastes that exist in any organization:

- unused human potential
- waiting
- inventory
- transportation
- defects
- motion
- overproduction
- processing (Kimsey, 2010, p. 54).

At Lehigh Valley Health Network in Allentown, Pennsylvania, the leadership team started the Lean journey by using the Plan, Do, Check, Act (PDCA) framework of problem solving. The PDCA methodology is similar to the Plan, Do, Study, Act system developed by Deming (The Deming Institute, 2015). The "Plan" segment of the process involves an assessment of the work where it occurs. Even if a leader has a "gut feeling" or personal experience, the purpose of Lean thinking is that every problem must be observed and investigated. The "Do" portion of the cycle for this organization involved the formation of rapid improvement teams that developed solutions to the problems. The "Check" segment of the PDCA cycle points to data analysis and outcome measurement. The "Act" portion of the cycle is when rapid adjustments are made to the solution and standardization of the process takes place through development of standard operating procedures (SOP) (Kimsey, 2010).

Using the principles of Lean, Collar and colleagues conducted an 18-month prospective, quasi-experimental study in the otolaryngology operating room in an academic setting (Collar et al., 2012). Operating room turnover and turnaround times were the variables. Turnover time (TOT) was defined as "the interval of minutes between patient departure from the OR, and the arrival of the subsequent patient in the OR" (Collar et al., 2012, p. 929). Turnaround time (TAT) was defined as the "the interval in minutes between surgical dressing end and surgical incision for the subsequent patient" (Collar et al., 2012, p. 930). The variables were observed for a baseline and again during a period when the staff was aware they were being observed (the observer effect group), but no Lean interventions were implemented. The impact on morale, teamwork, and surgical resident education was measured during both periods.

Individuals representing all of the aspects of the perioperative experience formed the interdisciplinary team of staff who carried out the Lean Implementation. The group mapped the current state processes using swim lanes and used these maps to identify the non-value added activities known as *muda*. The team examined the root causes of each *muda* and redesigned workflows to create new standard operating procedures. The processes of turnaround time and turnover time were studied over a period of two months with 258 turnover times and turnaround times.

The times for the baseline and observer-effect intervals of study showed no difference in turnover time (mean of 38.4 versus 38.3 minutes) or turnaround time (mean 89.5 versus 92.5 minutes). The TOT and TAT during the intervention period were statistically shorter during the same times in the baseline period. Turnover time was 29 minutes versus a baseline of 38.4 minutes, $p = 0.001$. Turnaround time was 69.3 minutes versus a baseline of 89.5 minutes, $p = 0.001$. Sixty seven percent of the TOTs during the intervention period were less than 60 minutes compared to 18.2% in the baseline period. Turnaround times experienced a similar reduction. Thirty-one percent of the TATs were less than 60 minutes compared to 13.7% in the non-Lean period. Cases extending past 5:00 pm also decreased from a baseline of 27% to 13%, $p = 0.16$. Morale of the staff in this study was measured using the SAQ Short Form. Staff morale improved from a composite score of 2.93 to 3.61, $p = 0.011$ (Collar et al., 2012).

This study is important to the capstone project because it used the SAQ Short Form as a means to assess staff attitudes, teamwork, and morale. These are issues often examined in studies seeking to use Lean or Six Sigma methodologies.

In a study to improve turnaround time and first case starts in the operating room, the staff at Montgomery Regional Hospital in Blacksburg, VA launched a process improvement team. The team was comprised of staff from many areas of the perioperative area as well as hospital leadership. The team used several Lean tools to define and analyze the current state and future state. To analyze the current state, the team used a process walk-through and a cause and effect diagram. Pareto charts, spaghetti diagrams, and time studies were also used in the process. To define the future state, they used brainstorming as a technique to determine solutions to the problems identified in the current state. A Kaizen event, which is a focused and structured improvement event conducted in an accelerated format, focused on workplace organization, the establishment of standard operating procedures, and implementing the processes needed to sustain the changes.

Results seen included a reduction in total inventory of nearly $22,000, a reduction in floor space for inventory and equipment in the OR by 38%, improved flow of the case picking area, and the creation of an audit process to maintain the system of organization (Glover, Van Aken, Creehan, & Skevington II, 2009).

Six Sigma

Six Sigma methodologies seek to achieve a defect-free environment through the reduction of variation in processes. Six Sigma uses data analysis to evaluate a process's ability to perform defect free and thereby, meet all of the customer's needs. Six Sigma projects are created using a methodology known as DMAIC, Define, Measure, Analyze, Improve, and Control (Woodard, 2005). The DMAIC method is closely aligned with the

Lean principles, PDCA and PDSA (Lifvergren, Gremyr, Hellstrom, Chakhunashvili, & Bergman, 2010).

In a study done at Valley Baptist Health System in Harlingen, Texas, leaders of a Six Sigma initiative sought to decrease operating room turnaround time. The two variables they studied were “patient out to patient in” and “patient in to surgeon in” (Pexton, 2010). Even though cycle times (the total time from the beginning to the end of a process) were within specified limits, there was wide variation that warranted investigation.

Valley Baptist Health System defined operating room defects for patient out to patient in as turnaround time greater than 20 minutes, patient in to surgeon in as greater than 25 minutes, and surgeon out to surgeon in as greater than 60 minutes. In this study, the project administrators determined that the most significant variations in processes took place with circulator/anesthesia communication, patient preparation and communication of patient status, and communication of surgeon arrival. Some of the project successes were a 15% improvement in OR turnaround time, increased OR capacity, and an estimated revenue increase of 1.3 million dollars a year (Pexton, 2010). This study is relevant to the capstone project due to its focus on unwanted process variation and the use of the Six Sigma DMAIC approach.

A significant dissatisfier for surgeons is the wait time for the room to be cleaned and restocked between their cases. Long wait times are also detrimental to patients who experience increased anxiety and fear if surgical cases are delayed. In a study by Adams and colleagues, a hospital system used the General Electric Medical Systems Healthcare Service to provide education on Six Sigma processes and tools. In the study hospital, surgeons had the expectation that room turnaround time was to be less than 30 minutes. Turnaround time was defined as the point where a surgeon leaves the room after finishing a case until arriving back in the room for the following case. Within this overall definition of turnaround time are three time intervals: surgeon out to patient out, patient out to patient in, and patient in to surgeon in (Adams, Warner, Hubbard, & Goulding, 2004).

One of the tools used for process improvement was a fishbone diagram, also known as a cause and effect diagram or an Ishikawa diagram. The fishbone diagram is useful for defining possible causes of a problem. Once a problem statement is developed, the fishbone diagram can serve as the basis for a brainstorming session. A fishbone diagram often centers on the following categories:

- Methods
- Machines (equipment)
- People (manpower)
- Materials
- Measurement
- Environment ("Fishbone Diagrams," 2014)

Once the Fishbone Diagram was developed, the team identified six performance improvement actions to pilot. Those actions were concurrent room cleanup, dismantling of the surgical setup immediately after closure, consistent assignments of staff, complete case carts, timely surgeon notification of room readiness, and increased assistance from anesthesia staff (Adams et al., 2004).

The results of the project demonstrated a statistically significant improvement from the baseline with a mean time of patient-out to patient-in decreased from 22.8 minutes to 15.6 minutes. Surgeon-out to surgeon-in was reduced 32%. Surgeon satisfaction was positively impacted as evidenced by results from physician surveys. This study is important to the capstone because it addresses key metrics associated with efficient OR operations. Improved room turnaround time is one of the key ways to maintain a positive hospital revenue stream. Results showed that the annual benefit to the hospital was approximately $162,000 (Adams et al., 2004).

Gaps in the Literature

The literature on Lean Six Sigma process improvement is plentiful. Multiple studies examining each of the concepts exist as far back as the early 1990s. While many studies show a clear benefit to the use of Lean and Six Sigma (Adams et al., 2004, Cima et al., 2011, Fairbanks, 2007, Glover et al., 2009), still others point to gaps in the literature. In a study published in 2010 by Jones and colleagues, the authors state that despite reports of huge saving in operations, Six Sigma has produced mixed results in industry due to its tendency to promote intense business competitiveness (Jones, Parast, & Adams, 2010). An editorial published in Fortune magazine in 2001 states that Six Sigma is nothing more than repackaged quality management principles (Clifford, 2001). Vest and Gamm examined the literature on nine Six Sigma and nine Lean studies. In order to be considered for the review, a study had to meet the following criteria:

- published in a peer-reviewed journal
- possessed a specific intervention
- was not classified as a pilot study
- provided quantitative data (Vest & Gamm, 2009).

The authors state that many of the studies displayed methodological limitations such as weak study designs and failure to rule out alternate hypotheses. Frequent omission of long-term sustainability of results was also cited (Vest & Gamm, 2009).

Strengths and Limitations of the Literature

Much of the literature related to healthcare process improvement possesses a strong focus on problem identification, proper use of Lean and Six Sigma management tools, detailed data analysis, and results reporting. Best practices in pre- and post-intervention data reporting are generally seen; however, more studies with this level of detail are needed. Additionally, many studies focus only on room turnover time as the primary process improvement. However, this minimizes the effect of other process improvement activities such as the use of dedicated rooms for surgical specialty; the use of accurate and complete surgeon preference cards, the basic organization and storage solutions in the OR, and the myriad of communication methods that improve patient care and efficiency. There is a general lack of literature focused on the effect of Lean Six Sigma interventions on safety attitudes of operating room staff. Using Lean and Six Sigma tools and the SAQ Short Form, this study adds to the current body of knowledge surrounding operating room efficiency and safety attitudes.

Conceptual Framework

The conceptual framework for this study was the Lean Six Sigma model of performance improvement. For the purposes of this study, Lean Six Sigma concepts focused on operational problem identification and the implementation of new and revised work processes. The Conceptual, Theoretical, Empirical framework illustrates the concepts for this study and is shown in Figure 1 below.

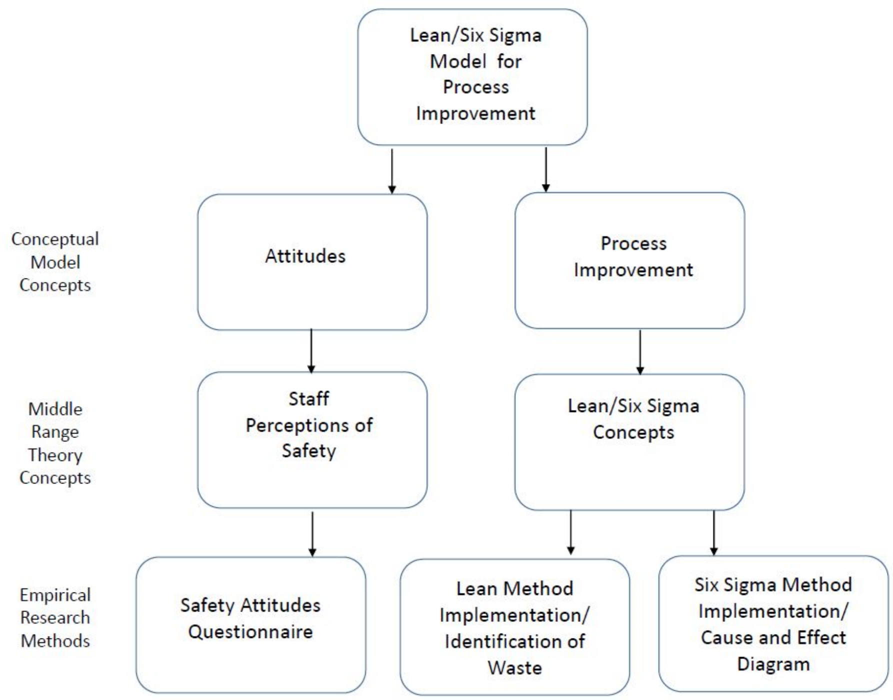

Figure 1. CTE Diagram Relating Lean Six Sigma to Capstone Project.

Summary

The literature related to Lean Six Sigma process improvement in the operating room is rich with examples of improved operating room efficiency. The issue of staff safety attitudes has not been studied widely in relation to operating room process improvement initiatives. This study addresses this gap in literature and seeks to improve operating room efficiency while maintaining positive staff safety attitudes.

CHAPTER III

Project Description

The purpose of this project was to identify the reasons for disruptions in operating room efficiency. Lean Six Sigma process improvement tools were utilized to accomplish this. Once the barriers to OR efficiency were defined, specific steps were taken toward improvement. Staff safety attitudes were assessed as they relate to OR efficiency initiatives.

Project Implementation

The project administrator received approval for the project from the university Institutional Review Board and hospital administration at the clinical site. The project administrator completed the Collaborative Institutional Training Initiative (CITI) through the university on June 24, 2013. The project utilized a voluntary pre- and post-assessment of OR staff safety attitudes called the Safety Attitudes Questionnaire Short Form. Historical data of OR metrics was analyzed and a current state assessment of throughput barriers took place. The current state assessment included the use of specific Lean Six Sigma tools such as a fishbone diagram, a cause and effect matrix, and the use of the PDSA model for process improvement.

Setting

The capstone project was conducted in the perioperative department of a community hospital in the piedmont region of North Carolina. The hospital is owned by a for-profit health system. The facility performed 1,628 inpatient surgeries and 2,989 outpatient surgeries in 2014.

Sample

For the purpose of this capstone project, a questionnaire related to safety attitudes was administered. The sample consisted of a group of operating room staff (physicians, nurses, technicians) who voluntarily completed the Safety Attitudes Questionnaire Short Form before Lean Six Sigma interventions. Twenty-two staff members from a potential of 37 completed the SAQ in the beginning of the project. Three of the surveys did not include key demographic information needed for the regression analysis so they were excluded from that portion of the findings. The response rate was 51%. After the Lean Six Sigma recommendations for process improvement were implemented, a second administration of the SAQ took place. Fifteen staff of a possible 37 completed the survey yielding a response rate of 41 percent.

Project Design

The opportunity for process improvement and the project goals were presented to the staff at a general staff meeting. An introduction to the principles of Lean and Six Sigma was carried out at the meeting. The common types of waste were reviewed and an overview of the study approach took place. Staff was informed that their participation in any part of the project was completely voluntary. The project began with a review of barriers to OR efficiency. The project administrator accomplished this by observing work processes on 11 different days in the OR. From this observation, the project administrator identified four primary categories of barriers: people, environment, materials, and methods. Staff participated in the identification of barriers through the use of a fishbone diagram. See Figure 2.

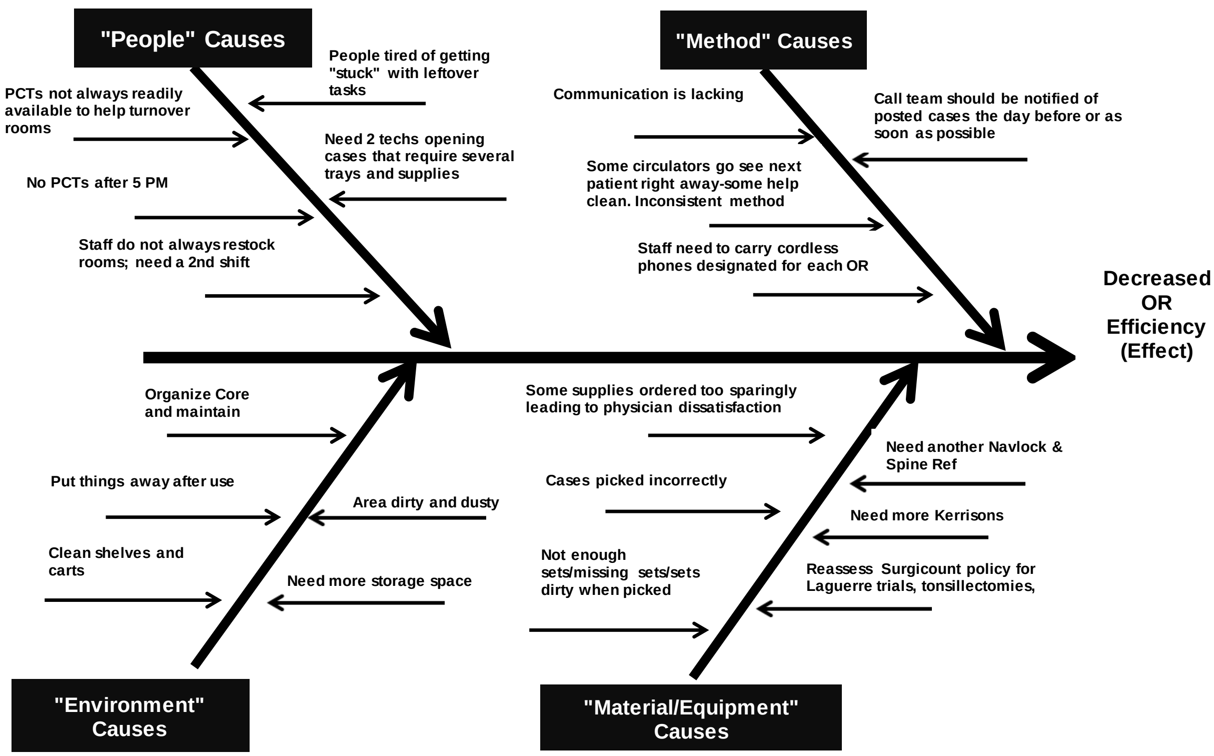

Figure 2. Perioperative Fishbone Diagram

At the same time, a SAQ Short Form was administered to all staff in the perioperative area who volunteered to participate. A current state map of the perioperative patient throughput process was developed as part of the initial assessment. Once this was finished, the information was validated for accuracy by the OR leadership team. See Figure 3.

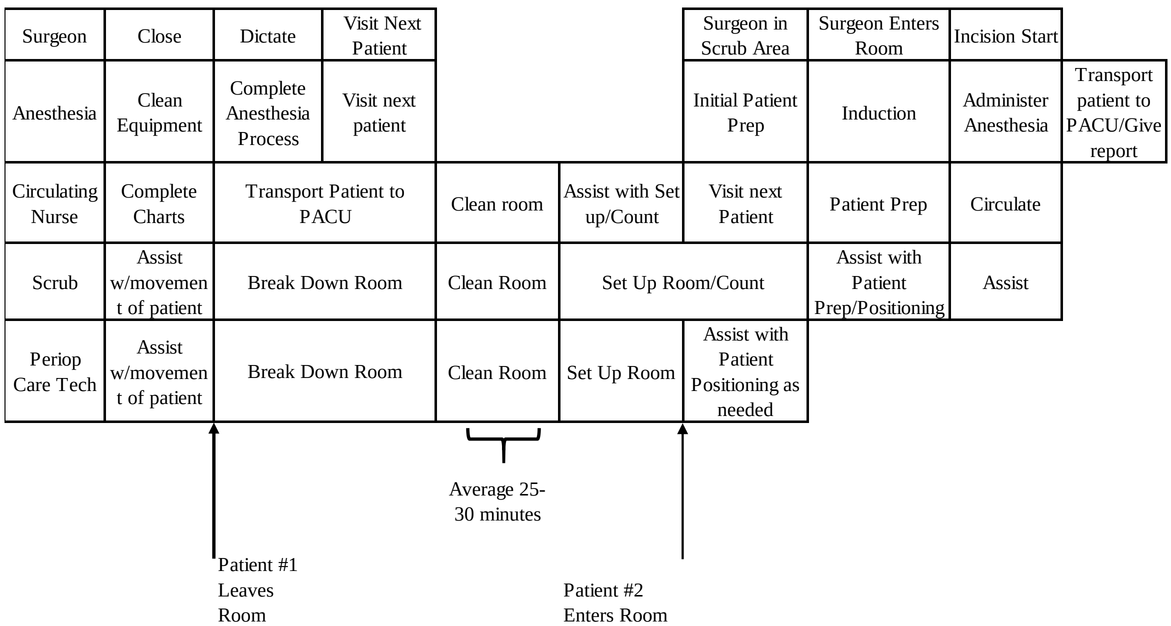

Figure 3. Current State Perioperative Process

Using the categories on the fishbone diagram as a starting point, staff members were asked to rank the importance of each barrier on a cause and effect matrix. The cause and effect matrix showed the key process input variables (KPIVs) directly related to the efficiency of the OR. These included timeliness of work performance, quality of work performed, information availability, adequate supplies and equipment, and appropriateness of work assignment. Using a scale where 1= no impact, 3=little impact, 5=marginal impact, 7=strong impact, and 10=very strong impact, the staff ranked each of the KPIVs against the barrier defined by the Fishbone Diagram. See Figure 4 and Table 1.

		Rating of Importance to Customer	**10**	**10**	**5**	**7**	**3**		
CAUSES	#	**Key Process Input Variables**	Timeliness of work performance	Quality of performed work	Information availability	Adequate supplies and equipment	Appropriate work assignment	**Total**	**% Rank**
People	1.	PCTs not always readily available	7	5	3	4	7	188	5.3%
	2.	No PCT after 5 pm	9	6	3	4	7	220	6.2%
	3.	Staff don't always restock rooms	7	6	2	7	5	210	5.9%
	4.	People tired to be stuck with leftover tasks	7	5	3	3	5	175	4.9%
	5.	Need 2 techs opening cases	6	5	2	4	4	160	4.5%
Environment	6.	Organize "Core" and maintain	7	6	3	3	4	174	4.9%
	7.	Need more storage space	7	5	3	5	3	185	5.2%
	8.	Area dirty and dusty	6	6	3	3	5	171	4.8%
	9.	Put things away after use	6	5	2	4	4	160	4.5%
	10.	Clean shelves and carts	5	6	3	5	4	169	4.8%
Method	11.	Communication is lacking	9	7	6	4	6	233	6.5%
	12.	Circulators (some to patients, some help cle	5	4	3	3	4	139	3.9%
	13.	Need to carry cordless phones	4	2	3	2	3	92	2.6%
	14.	Call team notification	6	4	7	2	3	146	4.1%
Equipment	15.	Supplies ordered too sparingly	7	5	4	6	4	196	5.5%
	16.	Cases picked incorrectly	8	5	4	7	3	213	6.0%
	17.	Not enough sets / missing sets / sets dirty	8	6	3	7	4	212	5.9%
	18.	Need another Navlock & Spine Ref	9	5	3	6	4	201	5.6%
	19.	Need more Kerrisons	8	5	3	7	4	197	5.5%
	20.	Reassess Surgicount policy	6	2	2	4	4	124	3.5%
		TOTAL	**137**	**97**	**66**	**90**	**87**		

Figure 4. Cause and Effect Matrix

The average scores for the above Cause & Effect matrix are calculated as the sum of all the respondents' scores for each KPIV divided by the number of respondents. Table 1 contains the ranking of the KPIVs according to the category of variable.

Table 1

Priority Ranking of KPIVs

Category	Variable
Environment	Need more storage space
Environment	Organize "Core" and maintain
Environment	Area dirty and dusty
Environment	Clean shelves and carts
Environment	Put things away after use
Equipment	Cases picked incorrectly
Equipment	Not enough sets / missing sets / sets dirty
Equipment	Need another Navlock & Spine Ref
Equipment	Need more Kerrisons
Equipment	Supplies ordered too sparingly
Equipment	Reassess Surgicount policy
Method	Communication is lacking
Method	Call team notification
Method	Circulators (some to patients, some help clean)
Method	Need to carry cordless phones
People	No PCT after 5 pm
People	Staff don't always restock rooms
People	PCTs not always readily available
People	People tried to be stuck with leftover tasks
People	Need 2 techs opening cases

At the conclusion of the rankings, the barriers with the highest ranking were identified according to the variable found in the fishbone diagram. The project administrator used this information to work with the hospital and OR leadership team to develop several interventions aimed at removing barriers to OR efficiency. The SAQ Short Form was administered a second time to determine if the interventions caused a shift in safety attitudes among the staff. The SAQ Short Form results were analyzed manually by a PhD-prepared statistician using Microsoft Excel®.

Protection of Human Subjects

No intervention using patients took place as part of this study. The staff who volunteered to take the SAQ Short Form was given an informed consent explaining that their responses are completely confidential at the individual level and would only be seen by the project administrator. Surveys were collected in sealed envelopes in a locked ballot-style box. Only the project administrator had a key to the box.

Instruments

The project administrator received written permission from the University of Texas at Austin to use the SAQ Short Form. The Safety Attitudes Survey (SAQ Short Form) is an instrument used to measure six safety-related domains by gathering input from frontline caregivers. The SAQ Short Form originally began as a 60-item tool. It was reduced to 30 items in the project administrators' efforts to produce a tool with a more satisfactory model fit. The tool's p value is <.0001 and another common measure of fit, the standardized root mean squared residual (SRMR) =.04. The SRMR is a popular fit indicator developed by Hu and Bentler (1999). Their research suggested a value of .08 or less as a guideline for good fit. Reliability of the SAQ assessed using Raykov's p

coefficient was .90, which indicated strong reliability. The percent of respondents within a clinical area who answered “agree slightly” or “agree strongly” on each of the items in a scale was the measure used to compute the percent positive scores (Sexton et al., 2006). The tool is scored for an individual respondent by reverse scoring all negatively worded questions. The mean of the items from the scale is then calculated. Next, one is subtracted from mean and the result is multiplied by 25.

Data Collection

The data required for this capstone project consisted of two administrations of the SAQ, one before any application of Lean Six Sigma interventions and one after. Other data elements included responses on a fish bone diagram and responses to a cause and effect matrix, which was used to prioritize the projects for improvement. All data collected were double password protected and the SAQs will be kept in a locked file cabinet at the University.

Data Analysis

The project administrator enlisted the services of a PhD-prepared statistician for data analysis. The statistician utilized Microsoft Excel® to analyze the data. The project administrator scanned and emailed the data from the surveys and the cause and effect matrix to the statistician. At no time was the data provided to the site in a form that would identify the participant.

Timeline

The timeline to complete the project was five months. The SAQ was administered at the start of the project. A current state map was developed and a fishbone diagram was used to categorize the barriers to operating room efficiency. A cause and effect matrix was utilized to prioritize the barriers that would be addressed. Additionally, brainstorming sessions took place between the project administrator and the OR staff to determine solutions to the barriers. Once the solutions were determined, a future state map was developed. The SAQ was administered a second time after the Lean Six Sigma tools were implemented.

Budget

The budget for the capstone project is shown in the Table 2 below.

Table 2

Capstone Project Budget

Expense	Amount
Copying of the SAQ	$30.00
Ballot box	$35.00
Envelopes for SAQ	$15.00
Cost for posters of fishbone diagram and cause and effect matrix	$15.00
Statistician	$350.00

Limitations

Initially this project was to specifically address workflow improvements related to room turnover time. As the project timeline grew and various aspects of the project began to unfold, it became clear that room turnover time was one of the most difficult metrics to influence. A change in this area required a great deal of planning and coordination between the nurses, surgeons, and anesthesia employees. It was determined by the project administrator and hospital leadership that this specific aspect of the project would be deferred for a future implementation. It was also noted that many other variables in the OR influence efficiency and specific measures were taken to address many of them.

Summary

The capstone project design was quasi-experimental using a pretest posttest method with the Safety Attitudes Questionnaire. The use of Lean Six Sigma tools such as, fishbone diagrams, cause and effect matrixes, and brainstorming for solutions occurred.

CHAPTER IV

Results

The purpose of this capstone project was to determine if the application of Lean Six Sigma process improvement tools had an impact on staff attitudes about safety and operating room efficiency.

Sample Characteristics

The first administration of the SAQ yielded results from 22 OR staff members. Three surveys were removed from the sample due to incomplete demographic information that was needed for the regression analysis. Twenty-one staff revealed their gender in the questionnaire. Twelve females (n=21, 57%) and nine males (n=21, 43%) completed the survey. The second administration of the SAQ resulted in 15 completed surveys with 14 having all the necessary information to perform a demographic analysis. Twelve females (n=12, 86%) and 2 males (n=2, 14%) participated. See Table 3 for the gender breakdown of each survey sample group.

Table 3

SAQ Gender Demographic

Gender	Female	Male
First Pass SAQ N=21	12 (57%)	9 (43%)
Second Pass SAQ N=14	12 (86%)	2 (14%)

In the first administration of the SAQ, 19 staff revealed their years in the perioperative specialty. The breakdown is as follows; 1-2 years = 1(5%), 3-4 years = 0 (0%), 5-10 years = 5 (26%), 11-20 years = 8 (42%) and 21 years or more = 5 (26%). In the second administration of the SAQ, 14 staff revealed their years in the specialty on the survey. The breakdown is as follows; 1-2 years = 1(7%), 3-4 years = 1 (7%), 5-10 years = 4 (29%), 11-20 years = 5 (36%) and 21 years or more = 3 (21%). See Table 4 for the years in the specialty breakdown of each survey administration.

Table 4

SAQ Years in the Specialty Demographic

Years in the Specialty	1-2 Years	3-4 Years	5-10 Years	11-20 Years	21 or more Years
First Pass SAQ N=19	1 (5%)	0 (0%)	5 (26%)	8 (42%)	5 (26%)
Second Pass SAQ N=14	1 (7%)	1 (7%)	4 (29%)	5 (36%)	3 (21%)

Major Findings

Following the first administration of the SAQ, each safety attitude domain was scored according to the instrument's scoring key. For the Teamwork Climate domain, the largest percentage of staff "agreed slightly" (n=8, 36.36%) with the questions in the domain. In the second administration of the SAQ, the Teamwork Domain showed the majority of the staff "agreed slightly" with the questions in the domain (n=7, 46.7). See Table 5 for an analysis of the responses for the Teamwork Domain.

Table 5

Pre-and Post-Intervention Scores for Teamwork Domain

	Percentage (prior)	Percentage (after)	Change
Disagree Strongly	4.55%	6.67%	2.12
Disagree Slightly	0.00%	6.67%	6.67
Neutral	31.82%	33.33%	1.52
Agree Slightly	36.36%	46.67%	10.30
Agree Strongly	27.27%	6.67%	-20.61

For the Safety Climate domain, the largest percentage of staff "agreed slightly" (n=22, 50%) with the questions in the domain. In the second administration of the SAQ, the largest percentage of the respondents were "neutral" (n=5, 33.3%). See Table 6.

Table 6

Pre-and Post-Intervention Scores for Safety Climate Domain

	Percentage (prior)	Percentage (after)	Change
Disagree Strongly	4.55%	6.67%	2.12
Disagree Slightly	4.55%	6.67%	2.12
Neutral	9.09%	33.33%	24.24
Agree Slightly	50.00%	26.67%	-23.33
Agree Strongly	31.82%	26.67%	-5.15

In the Job Satisfaction domain, the largest percentage of staff "agreed slightly" (n=9, 40.91%). In the second administration of the survey, the majority of the staff were "neutral" (n=4, 26.67%). See Table 7.

Table 7

Pre-and Post-Intervention Scores for Job Satisfaction Domain

	Percentage (prior)	Percentage (after)	Change
Disagree Strongly	18.18%	13.33%	-4.85
Disagree Slightly	9.09%	20.00%	10.91
Neutral	13.64%	26.67%	13.03
Agree Slightly	40.91%	20.00%	-20.91
Agree Strongly	18.18%	20.00%	1.82

In the Stress Recognition domain, the largest percentage of staff "agreed slightly" (n=14, 63.64%) with the questions on the first administration of the SAQ. On the second administration, the largest percentage of staff "agreed strongly" with the questions (n-6, 40%). See Table 8.

Table 8

Pre- and Post-Intervention Scores for Stress Recognition Domain

	Percentage (prior)	Percentage (after)	Change
Disagree Strongly	4.55%	6.67%	2.12
Disagree Slightly	0.00%	6.67%	6.67
Neutral	9.09%	26.67%	17.58
Agree Slightly	63.64%	20.00%	-43.64
Agree Strongly	22.73%	40.00%	17.27

For the Perceptions of Unit Management domain, there was a tie for “disagree strongly” and “neutral”, which were (n=5, 22.73%). In the second administration of the survey, the largest percentage of staff “agreed slightly” (n=5, 33.33%) See Table 9.

Table 9

Pre- and Post-Intervention Scores for Unit Management

	Percentage (prior)	Percentage (after)	Change
Disagree Strongly	22.73%	20.00%	-2.73
Disagree Slightly	18.18%	13.33%	-4.85
Neutral	22.73%	26.67%	3.94
Agree Slightly	18.18%	33.33%	15.15
Agree Strongly	18.18%	6.67%	-11.52

For the Perceptions of Hospital Management domain in the first administration of the SAQ, the largest percentage of staff were “neutral” (n=8, 36.36%). The post intervention scores were again “neutral”, (n=7, 46.47%). See Table 10.

Table 10

Pre-and Post-Intervention Scores for Perceptions of Hospital Management

	Percentage (prior)	Percentage (after)	Change
Disagree Strongly	18.18%	6.67%	-11.52
Disagree Slightly	18.18%	13.33%	-4.85
Neutral	36.36%	46.67%	10.30
Agree Slightly	18.18%	26.67%	8.48
Agree Strongly	9.09%	6.67%	-2.42

In the domain Working Conditions, the largest percentage of staff “slightly agreed”, (n=7, 40.91%) while in the second administration, there was a shift to “neutral”, (n=7, 46.67%). See Table 11.

Table 11

Pre-and Post-Intervention Scores for Working Conditions Domain

	Percentage (prior)	Percentage (after)	Change
Disagree Strongly	9.09%	6.67%	-2.42
Disagree Slightly	4.55%	6.67%	2.12
Neutral	31.82%	46.67%	14.85
Agree Slightly	40.91%	26.67%	-14.24
Agree Strongly	13.64%	13.33%	-0.30

A regression analysis performed for the first administrations of the SAQ did not reveal a linear relationship between the workers' years in the perioperative specialty, their gender, and any of the safety attitude domains. For the initial administration of the SAQ, the values of the coefficient of determination and F-statistics for gender (*coefficient*= 68.2926829, -10.823171, *f*=4.02875, and *significance f* =0.06090156) demonstrated that the model could not be declared valid. Based on the values of the coefficient of determination and F-statistics for years in the specialty (*coefficient*= 67.9000315, -0.2496056, *f*=0.23513, and *significance f* =0.63393522) the model was not valid. Based on the values of the coefficient of determination and F-statistics for gender and years in the specialty (*coefficient*, 75.4088305, -11.569069, *f*=2.350216, and *significance f* 0.127386821) the model was not valid. The absence of relationships between variables suggests there are other factors that influence the respondents' attitude, or some other type of relationship exists between the variables. Tables 12, 13, and 14 describe the statistics.

Table 12

Pre-Intervention Regression Statistics for Gender for all Domains

Regression Statistics						
Multiple R	0.43770189					
R Square	0.19158294					
Adjusted R Square	0.144029					
Standard Error	11.6046996					
Observations	19					
ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*	
Regression	1	542.5479	542.5479	4.02875	0.06090156	
Residual	17	2289.373	134.6691			
Total	18	2831.921				
	Coefficients	*Standard Error*	*t-stat*	*P-value*	Lower 95%	*Upper 95%*
Intercept	68.2926829	3.498948	19.51806	4.46E	60.9105467	75.6748191
Gender	-10.823171	5.399341	-2.00717	0.060902	-22.199806	0.55346521

Table 13

Pre-Intervention Regression Statistics for Years in Specialty for all Domains

Regression Statistics						
Multiple R	0.11680098					
R Square	0.01364247					
Adjusted R Square	-0.0443786					
Standard Error	12.8183861					
Observations	19					
ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*	
Regression	1	38.63440	38.63.44	0.23513	0.63393522	
Residual	17	2793.287	164.311			
Total	18	2831.921				
	Coefficients	*Standard Error*	*t-stat*	*P-value*	Lower 95%	*Upper 95%*
Intercept	67.9000315	9.0778047	7.47978	9E-07	48.7475377	87.0525252
Years in Specialty	-0.2496056	0.5147550	-0.4849	0.63393	-1.3356439	0.83643264

Table 14

Pre-Intervention Regression Statistics for Gender + Years in Specialty for all Domains

Regression Statistics						
Multiple R	0.47651788					
R Square	0.22706929					
Adjusted R Square	0.13045295					
Standard Error	11.6963651					
Observations	19					
ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*	
Regression	2					
Residual	16					
Total	18					
	Coefficients	*Standard Error*	*t-stat*	*P-value*	Lower 95%	*Upper 95%*
Intercept	75.408830	9.020715	8.359518	3.12E-0	94.5318923	94.5318923
Gender	-11.56906	5.504073	-2.10191	0.05175	0.09904498	0.09900449
Years in Specialty	-0.407696	0.475681	-0.85708	-23.237	0.60070324	0.60070323

A regression analysis performed after the second administrations of the SAQ failed to reveal a linear relationship between the workers' years in the perioperative specialty, their gender, and any of the safety attitude domains. When examining the values of the coefficient of determination and F-statistics for gender (*coefficient*= 59.7052846, 11.0264228, *f*=2.071811719 and *significance f* =0.17561501) the model could not be declared valid.

Based on the values of the coefficient of determination and F-statistics for years in the specialty (*coefficient*= 59.1835379, 0.14046554, *f*=0.105097877, and *significance f* =0.751376675), the model could not be declared valid.

Likewise in the post-intervention period, examining the values of the coefficient of determination and F-statistics for gender and years in the specialty (*coefficient*= 54.2483713, 13.0186292, *f*=1.334400874, and *significance f* 0.302790555), the model could not be declared valid. Tables 15, 16, and 17 describe these statistics.

Table 15

Post-Intervention Regression Statistics for Gender for all Domains

Regression Statistics						
Multiple R	0.38370736					
R Square	0.14723134					
Adjusted R Square	0.07616729					
Standard Error	10.0300039					
Observations	14					
ANOVA	*Df*	*SS*	*MS*	*F*	*Significance F*	
Regression	1	208.4263	208.4263	2.07181	0.17561501	
Residual	12	1207.212	100.601			
Total	13	1414.638				
	Coefficients	*Standard Error*	*t-stat*	*P-value*	Lower 95%	*Upper 95%*
Intercept	59.70528	2.895413	20.62065	9.75942	53.39672	66.01385
Gender	11.0264228	7.660542	1.439379	0.1756150	-5.6644643	27.71731

Table 16

Post-Intervention Regression Statistics for Years in Specialty for all Domains

Regression Statistics						
Multiple R	0.09317788					
R Square	0.00868212					
Adjusted R Square	-0.0739277					
Standard Error	10.8141392					
Observations	14					
ANOVA	*Df*	*SS*	*MS*	*F*	*Significance F*	
Regression	1	12.29074	12.29074	0.10509	0.75137667	
Residual	12	1403.347	116.9556			
Total	13	1414.638				
	Coefficients	*Standard Error*	*t-stat*	*P-value*	Lower 95%	*Upper 95%*
Intercept	59.1835379	7.084655	8.353764	2.40769	43.7474000	74.61968
Years in Specialty	0.14046554	0.433284	0.324188	0.75137	-0.8035795	1.084511

Table 17

Post-Intervention Regression Statistics for Gender + Years in Specialty for all Domains

Regression Statistics						
Multiple R	0.44186839					
R Square	0.19524767					
Adjusted R Square	0.04892907					
Standard Error	10.1767917					
Observations	14					
ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*	
Regression	2	276.4	138.2	1.33440	0.30279055	
Residual	11	1139.238	103.5671			
Total	13	1415.638				
	Coefficients	*Standard Error*	*t-stat*	*P-value*	Lower 95%	*Upper 95%*
Intercept	54.2483713	7.348551	7.382186	1.39069	38.074318	70.42242
Gender	13.0186292	8.152378	1.596912	0.12859	-4.924633	30.96189
Years in Specialty	0.34647068	0.427668	0.810139	0.43036	-0.594820	1.287762

Summary

The statistical data from the two administrations of the SAQ did not reveal correlations between the staffs' gender and years in the perioperative specialty when measured across all domains of the questionnaire. The data collected as part of the process improvement process showed several key areas that would benefit from a reengineering effort. Staff members in the OR were involved in the identification, planning, and implementation of all activities. A more detailed discussion of the results is included in Chapter Five.

CHAPTER V

Discussion

The purpose of this project was to determine if the application of Lean Six Sigma tools had an effect on OR staff perceptions of safety and on operating room efficiency.

Implication of Findings

The findings in this project relate to the purpose of identifying areas of inefficiency in the OR. The results of the SAQ both before and after the interventions did not suggest a correlation between safety and Lean Six Sigma implementation. There are a variety of reasons that this may have happened. First, the limited sample size, while ranging from 25-50% of the total OR staff, was likely too small, resulting in an inability to make generalizable correlations for future observations. Second, many of the survey responses were missing data. Staff may have felt intimidated by the process and were fearful that despite assurances that it was confidential, may have chosen not to respond for fear of reprisal. Using the PDSA model of performance improvement, the project findings are summarized below:

Plan

The planning phase of the project began with a meeting with hospital and OR leadership to describe the process for analysis of efficiencies. A kickoff meeting with the perioperative staff at their monthly perioperative meeting was held in June 2015. During the meeting, a detailed description of Lean Six Sigma methods, the various definitions of waster, the need for process improvement, and an explanation of the SAQ procedures took place.

Do

This phase of the project involved the administration of the SAQ, and development of the current state workflow. As the current state workflow was developed, the project administrator worked directly with the perioperative nurse educator to validate that the model was accurate. It was then approved by the director of perioperative services. Also as part of this phase, the project administrator spent 11 partial days in the operating room observing staff and workflow. Observation of processes, storage areas, case cart organization, patient flow, and specialized equipment usage took place. The project administrator held informal meetings with OR staff in their lounge during normal work hours as well as ongoing meetings with the OR leadership team.

Study

During the study phase it became evident there was a need for a change in workflow in order to gain efficiencies in room turnover times. The current state workflow demonstrated a delay in this metric. Based on the recommendation of the project administrator and research citing the recommendations for parallel processing (Friedman et al., 2006), the director of the OR agreed to propose a change in the workflow to anesthesia and hospital leadership. This change involved two primary role definitions, the circulating nurse and the nurse anesthetist. The circulating nurse's role in the current state involves taking the patient to the post anesthesia care unit (PACU). The nurse then goes back to the OR to assist with case setup. The circulating nurse then goes to the holding area and brings the patient into the suite for surgery.

In a parallel processing environment, the suggested workflow is for the circulating nurse to take the postoperative patient to the PACU, go to the holding area to visit the next patient and return to assist with room setup. The anesthesia provider would be responsible for bringing the patient to the OR suite no later than 20 minutes after the previous case ends. See Figure 5 for a proposed future state workflow.

Surgeon	Close	Dictate and Visit Next Patient		Surgeon in Scrub Area		Incision Start
Anesthesia	Clean Equipment	Complete Anesthesia Process		Pick up Patient from Holding Area/Patient Prep	Induction	
Circulating Nurse	Start Breaking Down Room	Complete Room Breakdown and Finish Charting/	Transport Patient to PACU	Visit Patient in Holding	Assist with Induction	Circulate
Scrub	Assist w/movement of patient	Break Down Room	Clean Room	Set Up Room	Open and Count	Assist with Patient Prep/Assist
Periop Care Tech	Assist w/movement of patient	Break Down Room	Clean Room	Set Up Room		

Patient #1 Leaves Room

Goal 20 minutes

Patient #2 Enters Room

Potential 10-30 Minute Time Reduction

Figure 5. Proposed Future State Perioperative Workflow

Parallel processing of this nature does not just happen. It requires months of planning and negotiation, in this case between nursing and anesthesia. During the course of this project, it was decided by the OR and hospital leadership to pursue process improvements outside the direct workflow changes. The issues identified in the fishbone diagram and the subsequent cause and effect matrix became the focus and provided many opportunities to make meaningful improvements.

Act

Several key solutions were implemented as a result of the fishbone diagram and the cause and effect matrix. See Table 18

Table 18

Issue Resolution Table

Category	Variable	Solution
Environment	Need more storage space	Comprehensive storage solution budgeted for 2016
Environment	Organize "Core" and maintain	Relates to storage solution
Equipment	Cases picked incorrectly	Hired surgical technician who is responsible for picking all next day cases
Equipment	Not enough sets / missing sets / sets dirty	More sets ordered and are budgeted for 2016 Implementation of specialized surgical instrument packs standardized by case type
Equipment	Need another Navlock & Spine Ref	Budgeted for 2016
Equipment	Need more Kerrisons	Kerrison just purchased/more in 2016 budget
Equipment	Supplies ordered too sparingly	Lack of storage plays role in the amount inventory. Dedicated rooms for surgery type (ortho, gyn, neuro, cysto, etc.) were implemented. This prevents the movement of large bulky equipment in and out of rooms for each case.
Equipment	Reassess Surgicount policy	This is corporate patient safety mandate-cannot change
Method	Communication is lacking	Weekly Friday Notes posted in lounge. Daily huddle implemented to assess next day cases and patient needs.
Method	Call team notification	Manager and Charge Nurse will assess need for late team before 12 noon each day and notify team
Method	Circulators (some to patients, some help clean)	Proposed revised workflow
People	No Patient Care Tech after 5 pm	There is now a PCT until 7PM
People	PCTs not always readily available	Stagger cases starts therefore completions will not all happen at once
People	Need 2 techs opening cases	Evaluate on a case-by-case basis by charge nurse

Application to Theoretical/Conceptual Framework

Process improvement using Lean Six Sigma tools has emerged as a viable approach to problem solving in health care. The project demonstrated that front line staff can participate in and implement changes that improve the patient safety and the work environment. The results of this capstone project related to the theoretical/conceptual framework that guided it. The CTE found in Figure 1 demonstrates that this framework was appropriate for the project using Lean and Six Sigma methodologies.

Limitations

One of the primary limitations of the project was the number of completed SAQs. It is unclear why there was limited involvement and incomplete data in some of the SAQs that were submitted. The fear of reprisal may have existed despite the assurance that all responses were confidential and anonymous. Only aggregate data was shared with the staff and leadership. Another limitation of the project was the inability to implement one of the key aspects of parallel processing; a change in the workflow of the operative suite. The acknowledgement of and respect for the viewpoints of all the stakeholders in the situation (nursing, anesthesia, support staff, and leadership) led to the decision to implement smaller scale improvements.

Implications for Nursing

This project has implications for perioperative nursing through its use of Lean Six Sigma methodologies commonly seen in non-healthcare settings. The project demonstrated that performance improvement activities could be developed with key stakeholders in the process, not just leadership. The project demonstrated that front line staff can actively participate in activities aimed at making the workplace safer and the environment more efficient for all.

Recommendations

It is recommended that future studies pursue the changes in workflow that would result in even greater improvements to perioperative efficiency. This will require a strong commitment to teamwork and negotiation between nurses, physicians, and support staff.

Conclusion

The findings of this project demonstrated that efficiencies can be gained in the perioperative area when staff members from several different disciplines participate in the process. The PDSA model of process improvement was used to guide the process. The Safety Attitudes Questionnaire was administered pre- and post-interventions. Although there were no correlations observed between the staff's perception of safety and the process improvement activities, this was potentially related to a small sample size.

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