CONTROL PHASE FOR A SIX SIGMA HEALTHCARE

EMERGENCY DEPARTMENT

PROJECT

THESIS

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This project involved application of Six Sigma tools and methods to improve the emergency department processes by decreasing length of stay and increasing patient satisfaction. The Gallup poll patient satisfaction survey at the hospital showed patients were dissatisfied with the amount of time taken in the Emergency Department (ED). A potential decrease in the patient wait time and increase in revenue was realized to answer both the Voice of the Customer and the Voice of the Business. Using Six Sigma tools and techniques, Define, Measure, Analyze, Improve and Control (DMAIC), the process was closely studied and the key problem areas were identified. The current controls for the

above factors were reviewed and actions were recommended for improvement. The project also included visits to Emergency Departments of other hospitals in the region in an effort to understand how similar problems were being addressed. After the recommended changes had been in place for one month, data analysis showed an improvement in patient satisfaction and decreased waiting times in the ED.

The process requires continuous efforts at improvement and monitoring to maintain the improved service at the ED. After a control plan was put into place, the hospital staff that were a part of the process improvement team would be solely responsible for maintaining the improved status. It is sometimes seen that without professional motivation and guidance, the staff may become too busy or not stay motivated enough to regularly monitor the ED processes and stop the ED from slipping back to the prior state. Similar data collection and analysis was completed after the changes had been in place for six months to study the effectiveness of the control phase in terms of patient length of stay, patient satisfaction and revenue earned by the hospital. The financial data for the months of October 2003 to August 2004 were obtained and used to analyze the economic impact of the Six Sigma process improvement project. The analysis showed that there was a significant decrease in waiting time after the changes had been in place one month and this improvement continued to be seen even after six months. Differences in length of stay were seen in the total length of stay, the time from triage to ED bed and from ED bed to discharge or admission. For both the Minor Emergency Clinic (MEC) and the non-MEC patients, a difference was seen in the time that the patient was in the ED bed. No differences were seen for any processes before the patient reached the ED bed. When the LOS for the MEC and the non-MEC patients was compared before and after the changes, a significant difference was seen for the non-MEC patients suggesting that the process had become faster. A difference was seen in the total length of stay, time taken from Triage to ED bed and time in the ED bed till discharge. These changes were reflected in the increased patient satisfaction ratings for the months after the changes had been brought about and also in the increased revenue that the ED generated due to improved and faster processes. The hospital had an increase in monthly ED earnings of $250,212 from October 2003, (when the project was started) to April 2004 (mean earning per patient = $719.97), when the changes had been in place for a month. The revenue showed an increase of $461,633 between the months of October 2003 (with a mean per patient = $ 576.00) and August 2004 (mean earning per patient = $756.58), when the changes were in place for six months. Also, it was seen that due to the improved process after the changes had been in place for six months, there was a steady rate of increase in revenue as seen from the fact that there was an increase in the total monthly earnings in August 2004 as compared to April 2004 ($ 211,421).

CHAPTER I

INTRODUCTION

The Emergency Department is the front door to healthcare services provided by a hospital. It is essential to make sure that emergency care to a patient is provided quickly and efficiently, which would increase patient satisfaction and also prove beneficial to the hospital in terms of reputation and financial benefits.

A recent report from the Centers for Disease Control and Prevention indicates that over the past decade trips to emergency departments (ED) increased 20 percent, while the number of available emergency centers decreased by 15 percent. Another study from the American Hospital Association indicated that 62 percent of hospitals are operating beyond capacity. That number surges to 90 percent when considering Level 1 Trauma Centers and larger (300+ beds) hospitals. According to a report from the General Accounting Office, two-thirds of Emergency Departments diverted ambulances during 2001 (Pexton, 2003).

A 1999 congressionally chartered report by the Institute of Medicine found that between 44,000 to 98,000 deaths in hospitals every year can be attributed to preventable medical errors. Medical errors can be defined as the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim. The highest error rates with serious consequences are most likely to occur in intensive care units, operating rooms and emergency departments (Institute of Medicine, To Err is Human, 1999). Besides death and disability due to these errors, there are many hidden costs for medical errors - personal incomes, years of potential life lost, rehabilitation costs and increased insurance premiums. These costs have been estimated to be between $17 billion and $29 billion per year nationwide (Institute of Medicine, To Err is Human, 1999).

Thus, a process driven reduction in medical errors would not only improve the quality of care received by the patient, but would also improve the health status of society. It would also save unnecessary expenditures due to medical errors helping to reduce the cost of healthcare.

Central Texas Medical Center

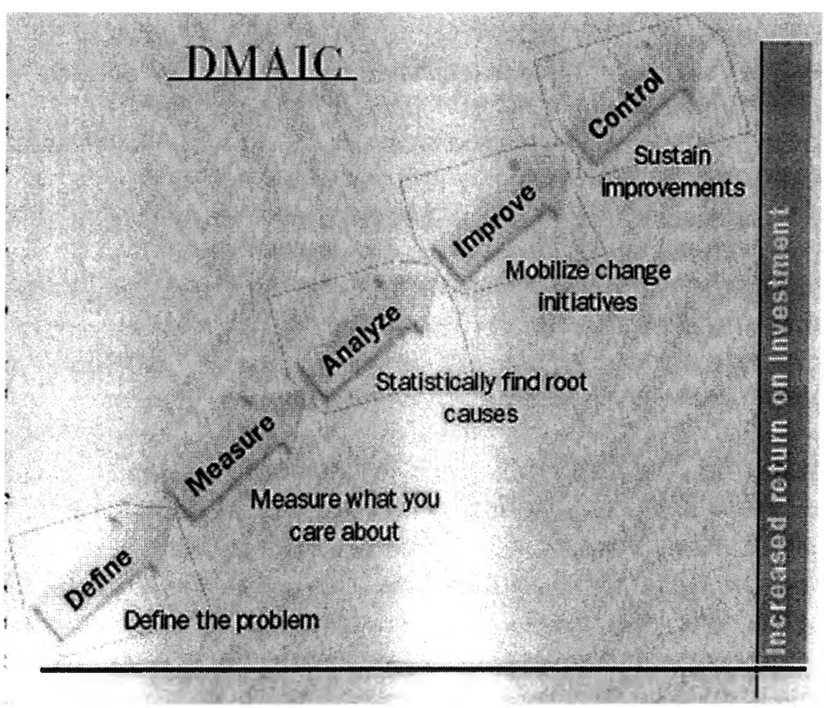
Central Texas Medical Center (CTMC), San Marcos, is a 113 bed acute-care general hospital and is part of the Sunbelt Adventist Health System which operates 37 hospitals all over the United States (About AHS, 2003). The hospital recently completed JCAHO certification with a total of 98 points out of a 100. The hospital is committed to improved performance and has recently acquired new information technologies as a step towards creating a paperless environment in the hospital. The hospital also collaborates with local schools and Texas State University to promote higher education and continuous improvement in healthcare. With an average of 92 patients per day in the emergency room and 2750 patients per month in 2003, the hospital has seen a 2 % increase in patient visits in the last two years. Even though Gallup poll data on patient satisfaction for the recent year has shown an increase in patient satisfaction levels from

4th percentile to 60th percentile, CTMC's patients have expressed dissatisfaction with the waiting time in the Emergency Department (ED). Thus, CTMC leaders were interested studying the reason why patients have long lengths of stay in the ED. How the ED processes could be improved and customer satisfaction levels increased were the aims for the project undertaken in October 2003.

Six Sigma Process Improvement

Six Sigma is a rigorous, data-driven, decision-making process. It utilizes a systematic five-phase, problem-solving process called DMAIC: Define, Measure, Analyze, Improve and Control as shown in Figure 1. DMAIC helps ensure that teams stay on track by establishing deliverables at each phase.

FIGURE 1: The Phases of Six Sigma Process



Motorola and General Electric, among others, have set reliability goals for the manufacture of their products and services that they describe as the quest for Six Sigma Quality (Ettinger, 2003).

As seen in figure 2, the Six Sigma level for defects per million opportunities (DPMO) is at only 3.4 DPMO, as derived from the six levels of DPMOs from the six standard deviations across a distribution.

FIGURE 2: Sigma Levels and Defects Per Million Opportunities

Sigma Levels

Sigma	Defects Per Million Opportunities (DPMO)
1	690,000
2	308,537
3	66,807
4	6,210
5	233
6	3.4

The process begins by defining the problem— and those things Critical to Quality (CTQ). Then, the performance of those CTQs is measured. Next, the situation is analyzed to find root causes of the problem and determine which problems have the most impact. With the causes identified, change is initiated to improve the process. Finally, it has to be ensured that the change lasts. The final step initiates measures to sustain the improvements made for long-term control.

This five-phase, DMAIC systematic approach is designed to dig in deeply, root out the problem and ensure the solution is sustainable.

Statement of the Problem

The project employed the use of Six Sigma tools and techniques to bring about changes in the Emergency Department in order to decrease the waiting time for patients. Since Length of Stay had been one area of dissatisfaction for the customers, it is expected that action on this front would increase satisfaction levels, improve the reputation of the hospital, and in turn bring in more patients which would mean more revenue for the hospital. Once the outside motivation for change was withdrawn, the hospital staff would be solely responsible for maintaining the changes and continuously improving upon them to keep up the efficiency and satisfaction gains.

Research Questions

1. Can Six Sigma tools and techniques be successfully implemented and maintained in a healthcare setting to bring about continual improvement in the processes in the Emergency Department?

2. Can the tools which were used to define, measure, analyze and improve the process be successfully used to control the waiting times over a continuous period of time?

3. Can the control plan be successfully and regularly monitored by the hospital process improvement team once active and professional help and motivation from outside help is no longer available?

4. Is there a significant difference in customer satisfaction levels after the implementation of the process improvements?

5. What does this change in the process and Length of Stay (LOS) mean in terms of revenue for the hospital? Does Six Sigma in healthcare translate into increased revenue from savings and gains, and is there a return on investment (ROI) for the process improvement project?

Significance of the Study

The literature regarding the use of Six Sigma tools in healthcare industry is rare and there are few examples of actual projects being undertaken in different hospital departments and their outcomes. There is also not much information on the control phase of projects and how improvements can be maintained and monitored over longer periods of time. If the process improvement team is not motivated or gets too busy in other routine activities, the processes will slip back to the old way once any outside or professional help is not available. It is important to see if the changes can be maintained over time and if the process improvement team can stay continuously motivated to look for other areas of improvement. To achieve this, they would have to maintain a statistically based, result-driven attitude to apply the tools and techniques on their own.

Limitations of the Study

Since the CTMC Emergency Department may function in a unique way, the same tools and techniques may not be applicable or as effective in other areas of the hospital. The study may also be constrained by the high expectations from the ED staff, and their drive to decrease waiting times. Since each ED is unique, the same techniques may not be as effective in every situation. After the improvements have been put in place, the entire process will be in the hands of the hospital staff to regularly monitor and continuously improve the processes to maintain the increased satisfaction levels of the patients and bring in increased revenue. The staff may get too busy or may not stay as motivated to pay attention to these aspects over long periods of time. The data collected for the study were tabulated from three different sources: the ER log book, direct observations and interviews with the staff. The accuracy and precision of the data could vary depending on the individual directly involved in data collection, transformation and analysis. In addition, the data gained from interviews are highly subjective. The inputs for the Six Sigma tools depend heavily on the perceptions of the project team members. Although the tools used a scoring system designed to target appropriate areas of opportunity, the inputs and use of the tools have some degree of subjectivity.

Glossary of Terms

5S - A key aspect of the Japanese river flow philosophy of production. It is comprised of 5 words that are the basis for process improvement programs. Seiri (Sort /Discard), Seiton (Arrange/Order), Seiso (Clean/ Inspect), Seiketsu (Standardize/ Improve), Shitsuke (Believe / Discipline).

Brainstorming - a free flow, unstructured, exchanging of ideas between key stakeholders for a particular problem, usually followed by a Pareto analysis.

Cause and Effect Diagram / Matrix - a pictorial chart used to represent causes that contribute or lead to a final effect. It is also called the Ishikawa diagram or Fishbone chart. This diagram is useful in group settings and for situations in which little quantitative data is available for analysis. An added benefit is that it can bring about a more thorough exploration of the issues behind a problem.

Control chart - A graphical statistical chart that provides a running log of the processes or attributes over time. Its benefit is being able to distinguish between common causes and special causes of variation.

DMAIC - The GE developed tenet of their Six Sigma methodology that consists of five process improvement stages: Define the problem, Measure the gap, Analyze to find root causes, Improve the process through identity, implementing and testing; and Control to hold the achieved gains.

Flowchart - A quality tool that is a graphical symbolic representation of the work performed in a process. The information in the chart usually shows start /stop, operation, transportation, inspection, delays and combined activity points for each stage within the process. It can also include information regarding quantities, distances, type of work done, and equipment used.

ICU - Intensive Care Unit

Kaizen - The Japanese term for improvement; continuous improvement activities that involves everyone in the organization. In Japanese "kai" means change and "zen" means good.

Lean Manufacturing - a manufacturing / production philosophy that emphasizes the minimization of the amount of all resources used in the organization. The goal is to shorten the lead time between customer order to the shipment of the product through the elimination of waste. It involves identifying and eliminating non-value added activities in design, production, supply chain management, internal processes, and business to customer interactions.

Murphy's analysis - a brainstorming technique

p-value - the probability of making a Type I error. Also, described as the probability of obtaining the same or more extreme data than observed when the Null hypothesis is true.

Pareto Analysis - The process of ranking opportunities for improvement for the purpose of deciding which opportunity to pursue first. It consists of three basic steps: List all the possible causes of the problem, collect data to determine the extent to which cause contributes to the problem, and rank the causes of the problem.

Poka-yoke - mistake proofing. An in-process quality control mechanism.

Sigma - the Greek letter σ. The symbol is used to designate the standard deviation of a population distribution.

Six Sigma Quality - a term used to generally indicate a process that is well controlled, the common causes of variation exist in plus or minus 3 Sigma from the centerline of the control chart.

SPC - Statistical process control

Total Quality Management - a term coined to describe a post WWII Japanese style of management. The style was characterized by an enterprise–side approach to quality improvements. Since then the term is now used to collectively describe the various methods and tools used to address quality issues.

Type I error - the case where one concludes that there is a special cause of variation when in reality it is not present.

Type II error - the case where one concludes that is there is no special cause of variation, in other words the variation is due to a common cause, when in reality a special cause is present.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Quantitative study designs have been used in quality improvement and assessment earlier, and the use and understanding of these techniques can help healthcare quality professionals make the most efficient use of their time, energies and resources. Quantitative designs are used when quality questions are narrowly focused and have identifiable goals or outcomes which can be measured (Ormes, 2001).

Healthcare has always been interested in improving their processes in various ways. Studies have been conducted on nurse-driven clinical process improvements to increase clinical, satisfaction and financial performance. A study was carried out in a 32 bed progressive care unit in a 325 bed regional referral center. Issues causing stress, frustration and dissatisfaction among the staff and leadership were studied. A plan was charted to improve patient flow, educate the staff, take measurements to study effectiveness of the project, and remove barriers related to inconsistent practices and lack of environmental organization. This rapid-cycle process improvement review of problem areas by the staff recommended changes and implementation strategies for changes. The problem areas identified were 1) communication between team members, 2) admission assessment complexity, 3) organization and availability of paperwork, 4) supplies and equipment, 5) frequency of vital signs and assessments and 6) inconsistent documentation expectations among staff. The changes which were put into place included peer feedback, organizing the supply cabinet, removal of the redundant parts of the assessment plan, decreased frequency of vital signs and assessment in unnecessary cases and use of pocket sized cards for documentation according to the accepted standards. This staff-driven, staff-implemented study was very successful and showed an increase in patient satisfaction scores from 10^{th} percentile to 94^{th} percentile (Sims, 2003).

Six Sigma was also used by Valley Baptist Health System, a not-for-profit community health network based in Harlingen, TX. Their 611- bed regional academic center used these techniques for maintaining appropriate staffing levels and improving productivity. The Valley Baptist System began to implement GE's Six Sigma Approach in 2002 as a rigorous methodology for process improvement and organizational change in the orthopedic nursing unit (Healthcare Executive, 2004). It was seen that the system was over budget not due to the expected reasons of sick leave, FMLA, vacation, and people not showing up, but rather was due to the staff matrix not being based on current data, disapproval of nurses floating in and out of units, and difficult to control processes involved in maintaining information in the matrix. Development of new standard operating procedures provided a plan the staff could follow and established accountability and resulted in increased patient satisfaction scores. The changes implemented due to the Six Sigma project led to $460,000 in potential savings for just one unit. The estimated savings for the whole system was $5 million. The Director of the Six Sigma operations in the system felt that the discipline and data foundation that's an integral part of Six Sigma and not in other process improvement programs, are what allowed the process improvements to be sustainable (Healthcare Executive, 2004).

The Emergency Department is the primary access to patients suffering from acute ill health and is one of the most demanding areas of the hospital in terms of staff, resources and time. Patient satisfaction levels in the ED depend minutely on the quality of care provided over a short interval of time. Hence, there have been many efforts to improve the quality of care provided. Using Total Quality Management (TQM) tools, in the ED admission process for cardiac patients at one academic medical center was carried out. Factors that were considered when identifying aspects of care included high-risk, high-volume, problem-prone and high-cost areas. A flowchart was developed and potential problems were identified. Data were collected by charge nurses and staff taking care of the cardiac patients. Keeping the target length of stay as 3 hours, a run chart was used to analyze the data collected when it was seen that only 13% of the patients had a length of stay less than the target. The initial charge after this analysis was to develop a clinical pathway for the management of these patients, which would define an optimal treatment plan to streamline care without compromising quality. These results laid the foundation for a new process improvement committee focusing on cardiac patients (Murphy,1995).

Another approach to improving ED processes has been multidisciplinary reengineering teams in emergency radiology services. At Overlook Hospital, New Jersey, since 60% of the emergency department patients were ambulatory, they could be seen as "fast track", to allow the patients to get out of the ED faster, to allow for more rapid turnover of ED rooms leading to greater capacity for the ED. "Arrival time to treatment" by emergency physicians was reduced from 31 minutes to 19 minutes and the X-ray cycle time was reduced from 60 minutes to 30 minutes, thus increasing patient satisfaction scores (Espinosa, 1997).

A large Los Angeles hospital also used reengineering to improve profitability and competitive advantage through cost reduction, shorter patient throughput time, reduced complaints, improved customer satisfaction, streamlined processes, and construction of process action teams for ongoing improvements. A diagnosis logic table was built to define the hospital objectives, success factors and controllable variables. Critical processes were charted using flow diagrams and data were gathered along with interviews and review of the hospital complaints in the past 3 years. Areas were selected for cycle time analysis and system optimization. The physical layout of the ED was changed, a new area was created for the low acuity patients to reduce wait-time. A computerized laboratory analysis system was put into place, new job descriptions and guidelines were set up. Better processes for managed-care authorizations, security, training, supply carts were implemented and a new system was put in place to alert the staff of empty beds in the ED (Schaming, 1998).

For more than a decade, U. S. hospitals have been adopting and implementing various total quality management programs that have the potential for reducing medication errors. In spite of this, medication errors continue to be a serious and costly problem for hospitals. Although TQM encourages data collection and analysis, it does not produce the level of detail required to understand process variation. As a result, development of a sustainable improvement plan is difficult. Six Sigma is a similar process to TQM, but with more aggressive goals and better defined data collection and monitoring methods (Revere, 2003).

"Will Six Sigma in healthcare work?" This has been a question which many are beginning to answer. In another study, error rates were investigated and calculated for various processes within ancillary services at Naval Medical Center, San Diego. These were translated into a common metric of defects per million opportunities (DPMO), which varied from 420,000 to 21.5; corresponding to Sigma values from 1.7 to over 5 respectively. Rates varied with the degree of complexity and degree of automation available. Some of the ancillary services translate well into Six Sigma, for example in medication warnings issued by the pharmacy (Sigma value = 1.7), to others with high risk potential like blood typing (Sigma value = 5.0) (Johnstone, 2003).

Other ED quality improvement studies were completed at Franklin Hospital Medical Center, North-Shore Long Island Jewish Medical System, Great Neck, N.Y. These studies had the objective to reduce ED hold time. These quality improvement efforts led to a 50% reduction in bed turnaround time in the hospital, 25% reduction in the average emergency department wait time, a significant decrease in patients leaving without being evaluated, and $226,000 in annual savings (Scalise, 2003). McLeod Regional Medical Center, Florence, S.C., reduced their service time by 25% and decreased customer and physician complaints by using Six Sigma tools to improve their registration procedures (Scalise, 2003). Six Sigma tools have also been used in reducing diagnostic lab delays in Froedtert Memorial Lutheran Hospital, Milwaukee. About 20 Six Sigma projects are underway at this hospital which has managed to reduce medical errors significantly (Scalise, 2003). At Memorial Hospital, Virtua Health, Marlton N.J., safety surrounding the weight based Heparin protocol was evaluated and the flow of activities involved in administering and monitoring heparin were mapped. The team at this hospital decided to simplify the process and error–proof the steps involved in the existing process. As part of the solutions, the hospital adopted a different version of the drug. The high cost of the new drug was offset by the time saved by the staff and net savings for the hospital. The hospital saved 198 minutes on average, per case, and $166,000-$406,000 annually (Scalise, 2003).

As more and more hospitals use Six Sigma methodology to improve everything from registration to patient safety, there has been an increasing trend in training hospital personnel as "Black Belts". Training costs range from $11,500 to $20,000 per Black Belt depending on the level of consultant support. These Black Belts can complete an average of four projects a year which typically yield $150,000 each in savings, for a total of $600,000 saved per Black Belt per year (Scalise, 2003). The initial cost is more than recovered once the hospital starts using Six Sigma tools to improve processes. It becomes more of a culture change once the staff at all levels have been trained to think about quality improvements.

The Emergency Department represents a financial lifeline for many hospitals and is arguably the top revenue contributor for many facilities. One in-patient admission from the ED per day, gained or lost, can make a difference of at least $3.65 million in annual gross revenue. The ED also represents 20 to 30 percent of a hospital's laboratory and radiology volume and revenue. Many factors affect the patient throughput process. Each factor needs to be assessed and measured against industry benchmarks. These benchmark data should be used to guide the process improvement projects (Karpiel, 2000).

A process redesign project was carried out at an academic setting in the university ED for the College of Medicine, Arizona. Being an academic hospital, the patients in the ED faced long waiting times and inefficient care before the project was started. As a result of the changes implemented, the median waiting time for the patient decreased from 31 minutes to 4 minutes within 6 months. ED throughput times also decreased, from 4 hours 21 minutes to 2 hours 55 minutes, the urgent care waiting room times decreased from 52 minutes to 7 minutes and throughput times from 2 hour 9 minutes to 1 hour 10 minutes. Patient satisfaction scores increased and this provided a new benchmark for all the EDs in an academic setting (Spaite, 2002)

Understanding how quality improvement affects costs is important; and costing can be difficult in healthcare as the processes are complex. Process based costing is one way to measure cost. This involves four steps: 1) developing a valid flowchart, 2) estimation of resources used in the process, 3) estimation of unit prices and 4) calculation of direct costs of the process. Costing studies can be participant-based, observer-based or mixed strategies. The observer-based strategy can be more expensive, but more reliable. This method can offer a clear strategy for process improvement and also can be directly applied to improvement activities (Lee, 2003).

There has been a lot of discussion on how to calculate the financial gains in Six Sigma projects. It is easier in manufacturing where each component has a fixed price. Costs can be evaluated and then used to calculate the financial gains or savings by looking at the material not used or wasted. In healthcare, there is a unique human factor problem. It is not always possible to put a price on service rendered by a healthcare provider or to estimate the savings made by changing a process. One possible way to do this would be to look at any staff /overtime changes which give an estimate of the money saved in salary or overtime payments or other benefits. This could then be added to the growth in revenue due to increased patient satisfaction which would then give the estimate of financial gains.

One of the more distinct differences between Six Sigma and other quality management systems is the link to business economics. Financial benefits of process improvement projects are quantified and used to help select and prioritize projects. Financial benefits are re-evaluated during the analysis phase to ensure that the cost of improvements will be supported by the benefits of the project. And finally, the financial benefits are verified once the project enters the control phase.

The quality profession has always been about improving processes, products and services. From TQM to Plan-Do-Check-Act (PDCA) to Six Sigma, all quality methodologies are focused on eliminating defects and the root causes of those defects. It involves products that satisfy customers, running processes at greater efficiencies, producing less waste and increasing business productivity. All of these, of course, are based on the belief that these processes are result in financial benefits.

If it doesn't make sense financially, would you still do it? In some cases you might, but as a rule of thumb you can't sustain a business unless you bring in revenue and produce a profit. The Six Sigma methodology, in particular, emphasizes the financial results of a quality improvement project (isixsigma, 2000).

How it works:

1. Before a project is initiated, an analysis of financial benefits is performed. This allows management to prioritize, along with other business specific factors, potential projects

2. After or during the completion of a project, a final financial analysis is performed based on the actual results of the project. This forces the business to quantify the return on investment (ROI) for the quality department. Is it paying off as you would expect any other investment in the business?

3. A Six Sigma project opens the eyes of management to what is actually happening on the floor, in the shop and in the cubicles, translating day-to-day activities into terms that they are concerned about - meeting the budget, increasing profits and driving shareholder value.

4. A Six Sigma project further educates employees about the whole financial picture. Because Six Sigma uses employees to drive projects and improvements, it also modifies their work behaviors to cut costs and increase profits (isixsigma, 2000).

Many quality indicators are not expressed in common financial terms. For this reason, executive managers often find it difficult to evaluate quality-related performance (Heinloth, 2000). One way to do this would be to identify the major factors involved like people, materials, machines, methods and then to assign a dollar value to each of these factors. To affect profit, quality must address either income or expense. "Good quality" can increase revenue / income and reduce the expense due to wastage. Thus increases in efficiency and reduction in production cost can be counted towards financial gain for an organization. This analysis can only be done in retrospect. Two additional aspects should be considered when analyzing quality's return on investment.

- Investment vs. expense (prevention vs. correction): Is the investment on the process improvement projects worth it? Will it save money that is being wasted on correcting errors? Is the cost of prevention more or less than the cost of correction? The prevention cost can avoid continuous waste of resources in correcting the same mistakes.
- Scope of quality: Is there a real scope for improving quality? Are there enough resources, manpower and motivation to improve quality even though the effects may not be readily visible?

In the financial world there is a clear distinction between investments and expenses. This distinction should be applied in the arena where preventive action is planned. Costs need to be calculated as does the expected benefits (return) to evaluate preventive action. Expenses on the other hand cannot always be linked directly to measurable returns. Corrective action qualifies as an expense, but this is an expense caused by lack of quality. Managers have learned that preventive action is more beneficial to an organization than corrective action (Heinloth, 2000).

One of the manufacturing proponents of Six Sigma is General Electric (GE) which has achieved tremendous success applying its concepts in both manufacturing and office procedures. Across the company, GE embraced Six Sigma's customer focused data driven philosophy and applied it to everything they did. Six Sigma delivered $2400 million to the bottom line profits in 2000 at GE (GEindustrial, Six Sigma financial benefits, 2000).

A telecom company in Korea, (KT) announced in March 2004 that they achieved significant financial benefits in the first wave of their Six Sigma process improvement efforts. KT is reported to be the first firm in the telecom industry to have implemented a Six Sigma management system. They have successfully completed 452 projects in 7 areas (sales creation, improvement of profit leakage, cost reduction, curtailment of investment, enhancement of productivity, lead time cut down, and quality improvement) achieving a total of $41 billion in savings. KT plans to actively use Six Sigma as their key driver for management quality improvement in the future. They expect financial benefits totaling over $100 billion in 2004.

Total quality control reduces operating costs as stated by Feigenbaum, who said "Quality and costs are complementary, not conflicting business objective." Quality costs are identified as follows:

(1) Prevention costs, which include quality planning and other costs associated with preventing non-conformance and defects,

(2) Appraisal costs, incurred in evaluating product quality to maintain established quality levels,

(3) Internal failure costs, caused by defective and nonconforming materials and products that do not meet company quality specifications, and

(4) External failure costs, caused by defective and nonconforming products reaching the customer.

Many case studies in manufacturing and service companies demonstrate investment in prevention costs is far outweighed by savings in internal and external failure costs. The costs of failure for the customer often outweigh the external failure cost to the producer. In healthcare there is a paradox: Sometimes internal failures lead to an increase in revenue through fees for additional corrective services or movement to a higher diagnostic related group in the federal payment classification system. External failures can also lead to more care such as readmission, additional office services, and laboratory testing. Therefore reducing failures through total quality control in healthcare can reduce the bottom line, unlike other industries. Studies for specific projects designed to improve quality are often unable to demonstrate a positive return on investment for the provider (Schyve, 2004)

Many hospitals today are familiar with the Juran trilogy: quality planning, quality control and quality improvement. Quality planning is about building quality into the processes from the start. An example would be opening a new health center with patient centered processes, and with trained and effective staff. Quality control is about maintaining the performance of a process. For example, many emergency departments now monitor waiting times with control charts and spreadsheets to help identify delays in patient service. Quality improvement is about changing a process to improve performance. Costs may be costs of quality (poor vs. high quality) or costs of variation (differences in the process can require more extensive training) (Bisognanao, 2004).

The ultimate quality award is improving the bottom line. Satisfied customers come back for more and encourage business associates, family and friends to do the same. Six Sigma has become popular because it delivers measurable, tangible economic benefits.

The cost of poor quality is commonly used in industry as a key criterion for the selection and evaluation of Six Sigma Projects. For example Black Belt projects typically save $250,000 or more and the Green Belt projects frequently yield savings from $50,000 to $75,000. Such figures are even more impressive when taken in aggregate and in wider context of the company's other economic figures. Even though it may not count as increased revenue unless more customers are served, it still means increased revenue for the company/ healthcare facility when savings accumulate. This is sometimes called cost avoidance or "soft dollars". To account for the increased revenue we would have to calculate the return on investment which would be a fixed cost for the period in which the project is expected to bring in returns. It provides a rough measure of the significance of the benefits of the investment (Bisgaard, 2004).

The key for quality improvement and control in small scale projects is to weave them thoroughly to the fabric of daily work which brings the idea of flawless execution closer to reality and provides substantial financial benefits necessary to make the effort worthwhile. The middle ground of Six Sigma encompasses three steps of increasing magnitude:

1. Select two or three areas in which to initiate Six Sigma,
2. Spread it to adjacent areas as you gain experience with Six Sigma in each of the initial areas, and
3. Integrate the improvement efforts, including capital projects, into an overall organizational improvement system.

The widely dispersed experience gained in the first phase will enable more rapid propagation of Six Sigma to other areas. The goal is not only to implement Six Sigma as needed but to maintain and sustain its techniques to lay the groundwork for continuous improvement and the achievement of competitive and financial benefits. Through continual portfolio review, assessment and evaluation, improvement efforts can be coordinated to ensure that the organization stays focused on improvement and control so improved performance does not deteriorate. Success in a Six Sigma project does not come from a metric or a deadline but when the elements of the system become daily routine. Some of these elements include:

- Working to find better ways of doing things,
- Finding ways to improve a bottom line,
- Thinking of everything you do as a process,
- Recognizing the ubiquity of variation and its effects on work,
- Working to reduce variation,
- Using data to guide decisions, and
- Maintaining a joint focus on improvement and control.

(Snee, 2004).

General Electric, which has been a strong proponent of Six Sigma, claims to have made $750 million due to Six Sigma improvements in 1998, with another estimated $1.5 billion in 1999. Their operating margins continue to make records and are attributed directly to Six Sigma. Another example is Motorola, which laid the foundations of the Six Sigma concept, and has also enjoyed tremendous long term successes: 500% growth in sales, estimated savings of $14 billion, nearly 20 % profit growth for a decade, and the prestigious Malcolm Baldridge National Quality Award (Westgard, 2000). The savings from Six Sigma improvements vary from 1.2%-4.5% of revenue. (Waxer, 2000).

Mount Carmel Health System, a three hospital health system in Columbus, Ohio, has 403 six sigma projects completed or ongoing, and has identified $38 million in savings - $11.6 million alone during 2004. The system had a negative 51% return on investment (ROI) in the first year while gearing up its Six Sigma program, but had a 100% return in the second year and a 500% return in the third year (Goedert, 2004).

With the huge size of the institution and its various departments, M.D. Anderson has focused in quality improvement and has more than 400 projects that have used Six Sigma tools and techniques or other quantitative statistical techniques for process improvement. One of the theories used is the Theory of Constraints which is a deterministic approach of using performance and service measures to pinpoint what needs to change first and how they impact the whole. When this type of thinking prevails at the department level and the organizational level, weak points of service delivery are quantified so efforts can be taken to strengthen them. Energies and resources can be exerted on those areas that impact the throughput and quality of service the most. Finally, each department knows their "link" to the enterprise-wide service delivery picture and how to change in order to make the maximum benefit to the whole.

They used the error-crucifying elements of visual control (otherwise known as visual organization), knowledge management (growing knowledge in a learning organization), communication (shared understanding) and management of design (including mistake-proofing), i.e. using a new electronic transportation vehicle that was introduced into a healthcare environment. The transportation vehicle came equipped only with an operator's handbook. Instead of giving time consuming training (along with variable understanding), the environment around the machine was laminated with the dos, don’ts, and warnings; it was easier to put up notices which showed the correct and incorrect way of handling equipment. It was easy for staff to understand and got the message across in a quick and easy method.

There are five levels of visual control, which if judiciously applied, will minimize most of any systems’ unmindful errors:

- Sort through and sort out,
- Set things in order,
- Shine,
- Standardize, and
- Self Discipline

Another method M.D. Anderson used is Red Tagging which involves creating a red tag file and putting in it folders and files which have not been used for some time or are not needed at that time and place. These are then placed in the red tag file, and if they are not claimed for a certain period of time, they are removed from the system after adequate warning.

How do you devise things so they can only be done the right way? Make it a force-function. Mechanically design it so there is only one way to choose: the right way. That way you are not relying on the variability of human judgment. For example, if there is only one way that a blood sample bottle can be placed in the analyzer, there will be no chance of making mistakes simply because it will not be possible to place the sample bottle any other way in the analyzer. This is the basis of the Japanese concept of Poka Yoke, which has also been called by Shigeo Shingo, the originator of the concept, as idiot-proofing.

To maintain the improvement and increase savings and revenue, it is important to have a proper control plan in place which will continually monitor the changes implemented and also see new areas where changes can be made, making the process more efficient and improving quality. As the sigma level of a process moves beyond three, practical problems in interpretation of the charts may arise when conventional charts are used. Alternative techniques are useful in this case to control a process which has successfully been improved (Goh, 2003).

A control chart is a statistical process control tool which "provides a pictorial representation of what you measure over a period of time and allows you to identify when special causes of variation are active in your process." According to author D. Lynn Kelly (American Health Consultants, 2004).

The control chart which is used most often was developed by Walter Shewhart (1931), and is named for him. The Shewhart control chart is used for a similar purpose as a run chart: to differentiate between common cause variation and special cause variation produced by a process. A run chart is a simple construct and can be used to analyze the type of variation that is present in a process. The type of chart used for a process depends on many factors. The charts for measurement are more powerful than uncharted attribute data, and the aim of a project should be to collect the data to use the best chart and not just the correct one (Carey, 2002).

It can be difficult to maintain an initial pace of improvement, especially since people get tied up it the day-to-day operations and they do not have time to devote to the level of detail that may be required–nor can they develop the level of sophistication or competency, as happened in Charleston Army Medical Center, a 919 bed, three campus non–profit medical center (Simmons, 2002). After showing initial improvements in processes, the system slipped back to the prior state simply because no effort was made to continue and sustain the improvement effort.

Lean and Six Sigma

It is often felt that Six Sigma and Lean are complimentary tools. There may be cases where the two techniques are launched exclusive of each other and other cases where they are used together. So, it is important to recognize the differences between the two. These two tools are techniques to avoid or eliminate tasks which are non-value added. Waste is an enemy in the Lean enterprise. Waste can be of various types like overproduction, inventory waste, defective product, overprocessing, waiting, waste of people's skills, or unnecessary movement of man or material. In comparison to the concepts of Lean, Six Sigma recognizes three types of waste - defects, variation and unwanted products. The building blocks which support the identification and elimination of waste in the lean technique also support the goals of waste elimination in Six Sigma techniques (Alukal, 2003).

The lean building blocks are used to introduce, sustain, and improve a lean production system. The common building blocks are:

5S - The foundation of workplace organization and standardization. It is comprised of 5 words that are the basis for process improvement programs. Seiri (Sort /Discard), Seiton (Arrange/Order), Seiso (Clean/ Inspect), Seiketsu (Standardize/ Improve), Shitsuke (Believe/Discipline).

Visual Controls- the entire manufacturing system should be able to be understood at a glance - tools, materials and processes are clearly positioned marked so that there is no mistaking the status of each item or process.

Streamlined layout - the entire plant is physically designed to optimize the pull of the product or information through the facility.

Standardize work - specific methods of assembly and processing are designed to eliminate sources of variance and unwarranted motion. Tasks are completed safely in accordance with ergonomic standards.

Batch size reduction - This reduces all types of inventory and allows all stakeholders to detect potential problems early. If a lot size of one (optimum) is not feasible, then the goal is to reduce batch size to be as small as possible.

Teams – fundamental concept, regardless of the type of work to be completed.

Quality at the source - the operators themselves inspect for quality. A work piece passed down the manufacturing line is known to be of acceptable quality.

Point-of-use storage - material, work in process, tools, work instructions and information are stored where they are needed.

Pull and kanban - the product being produced is pulled downstream through the factory by the end customer. An upstream supplier does not produce anything until a downstream customer signals a need for their product via the use of a kanban system.

Cellular of flow - the physical linkage of workstations or cells in an efficient manner in order to maximize added value and minimize transport waste.

Total productive maintenance - the discipline of periodically maintaining tools, equipment, workstations, and the facilities to maximize production effectiveness.

Quick changeover - the flexibility of being able to change tooling and fixtures rapidly in order to produce a range of products in small batches.

Many of these building blocks can be used without the statistical underpinnings that are evident in Six Sigma methodologies. So, Six Sigma practitioners should view the building blocks within the Lean techniques as enablers for Six Sigma projects (Smith, 2003).

The difference between Lean and Six Sigma lies in the methodology. Lean techniques are biased towards action and intuition. The users of Lean methodologies are faster to act upon a perceived problem. In contrast the users of Six Sigma techniques may spend six months or more on a single project. This may result in the perception that the momentum for transforming a process is lost. By combining both these techniques, users can quickly eliminate obvious problems and begin processing the more difficult problems within the organization (Smith, 2003).

Caution should be exercised however when applying Lean techniques in healthcare settings. It should be obvious that lower levels of inventory or batch size reductions could have disastrous effects in emergency situations. If, for example a hospital was deluged by patients in an emergency situation it would not be effective to stock small amounts of medicine or to treat clinical patients in lot sizes of one unit. So, lean techniques should be applied thoughtfully and selectively in any healthcare environment.

CHAPTER III

METHODS

General Approach

Central Texas Medical Center's (CTMC) Emergency Department (ED) is a complex environment which has a many processes and sub-processes going on at the same time. The ED runs continuously 24 hours a day and 365 days a year. The processes involve people both as healthcare providers and patients which makes it even more complex due to the human factors at work. It was beneficial to involve people from all departments of the hospital in the process improvement effort, along with a Six Sigma black belt, four graduate students and one undergraduate student who participated in the project. All the study team members went through two days of hospital orientation in August - September 2003. Once the orientation was complete, the members were allowed to observe the ED processes. The study took a detailed look at the processes involved in providing care to the patients as they came into the ED, and noted the various sub-processes involved. Additional notes were made about the staff schedules, problems observed and expressed by the staff, sources of data, general layout of the facility and the equipment used to process the patients. This allowed the team members to become familiar with the processes involved and how the patients flow through these processes.

The Six Sigma tools used in this study require involvement of the employees of the hospital at all levels, not only to help in mapping the processes, but also in suggesting failure modes and improvements. Involvement of employees from many departments which interact with the ED helps ensure sustainable results and constant review of the processes.

Development of the Project Team

An initial meeting was held on October 6, 2003 in which methodologies and goals of the Six Sigma project were introduced to CTMC's leaders. The scope and potential need for resources was also discussed. The set of leaders in attendance included the CEO, Director of Support Services, Vice President of Nursing, Emergency Department Clinical Nursing Manager, Director of Emergency Department and Informatics, Manager of Management Information Systems, and the Emergency Medical Director. The leaders agreed to embark on a cooperative effort between the hospital, Texas State University and Sigma Breakthrough Technologies Incorporated (SBTI) to make quality improvements within the ED. The Director of the Emergency Department, Director of Informatics, and the Emergency Department Clinical Nursing Manager were assigned to lead the internal team for the project. SBTI, an internationally recognized consulting company provided technical help and training for the project.

DMAIC

A SBTI Black Belt Six Sigma champion, helped create a Microsoft project Gantt chart that served as the tool for project management and its various steps. On October 17, 2003 the first meeting of the project members was held to identify the Voice of the Customer (VOC), the Voice of the Business (VOB), and the development of Murphy's analysis.

VOC

At CTMC, patient satisfaction is measured by the Gallup Poll. The Gallup Poll results provide ratings weekly and the collected ratings are used to give the quarterly ratings of customer satisfaction. There is also an internal survey conducted over the telephone by the employees on a daily basis. The internal survey involves asking the patients to rate their satisfaction levels on a Likert scale from 1 to 4 for 10 questions. A score of 4 means "very satisfied" and a score of 1 means "very dissatisfied". The questions are as follows:

Did you feel that the ED staff was attentive to your needs?

Did you feel that the ED staff was responsive to your requests?

Did you feel that the ED staff demonstrated care and compassion?

Did you feel that the ED staff provided you with an adequate explanation of medication and procedures?

Did your family members feel like they were kept informed of your progress?

Did you feel that the ED staff respected your privacy/confidentiality?

Did you feel that your brief interview with the triage nurse was completed in a timely manner?

Did you feel that your lab and X-ray procedures were completed in a timely manner?

If you experienced a delay, were you kept informed?

Did you feel that the discharge instructions were adequate?

SIPOC Map

On October 24, 2003 The SIPOC (Supplies, Inputs, Processes, Outputs, and Customers) map was constructed by focusing on the top 5 or 6 high-level steps in ED processes. A basic process map was built which showed that there were five stages for patients presenting themselves to the ED: 1) presentation to the triage, 2) registration, 3) assessment, 4) management and treatment, and 5) disposition of the patient. The process was presented in the form of a flowchart where the patient first presents to Triage to determine the level of severity of the presenting complaint. If the severity is low, the patient goes to the registration desk where his or her information is entered into the computer system. The patient is then taken into the Emergency Room for further assessment by the nurse and physician. After this, patient management includes diagnostic tests and treatment. When management is complete, the patient is either discharged, transferred to another floor, or to another hospital. Some patients leave without being seen or against medical advice due to various reasons.

These five process steps were used to build a SIPOC (Figure 3), which was a chart to show the process step in the middle, the inputs for the process step to the left (patient, nurse, chart) and the outputs of that step to the right (patient presents to registration, chart). In addition each step also included sub processes. The outputs for each step automatically served as inputs for the next step. This is the point where the process was defined.

Cause and Effect (C& E) Matrix

The SIPOC map was used to create a Cause and Effect Matrix which helped prioritize the steps needing more attention. The outputs for the SIPOC map are listed at the top of the matrix as measurable requirements. Each measurement is assigned an output rating score on a scale of 1 to 10. Higher scores indicate that the output was more important to the customer. Then the team assigned relationship scores between each of the process inputs and each output requirement.

The levels possible were:

0 = no relationship

1 = the process input is slightly related to the output requirement

3 = the process input is moderately related to the output requirement

9 = the process input is strongly related to the output requirement

Finally the sub-score for the process inputs are calculated by multiplying the respective ratings of importance to the customer and the relationship score for each cell in the process input row. Each of the sub scores are added together to yield a total score for the process input. The highest total score identifies those process inputs that are the most important in explaining the variation in the process outputs. These inputs are then entered into the Failure Modes and Effects Analysis (FMEA).

Failure Modes and Effects Analysis (FMEA)

The next step is the failure modes and effects analysis which is the primary tool for risk assessment. The inputs include the result from Murphy's analysis, SIPOC and C & E matrix. The output yields a list of defects to be measured, a prioritized list of actions to improve processes, and the basis for a process control plan. The FMEA was constructed in December, 2003. Each process input from the C & E matrix is used as a header in the FMEA. For each of these inputs the failure modes are identified (what can go wrong with the input?) and the potential failure effects (What is the effect on the output?). Then a Severity score (SEV) is assigned to the input (between 1 and 10 where 1 represents the lowest severity effect). Next, the potential causes of the failure modes are recognized and assigned an Occurrence (OCC) score (1-10, with 1 representing the least likely occurrence). The current controls are then discussed and entered in the FMEA with a Detection (DET) score (1-10 with a score of 1 representing the highest probability of detection of the failure mode). Finally the Risk Priority Number (RPN) is calculated by multiplying the Severity, Occurrence, and Detection scores together for each process input. The RPN is the output of the FMEA and serves to prioritize process improvement actions. High RPN numbers denote prime opportunities for improvement efforts. The process inputs identified in the FMEA serve as the focus for the Analysis and Process Improvement stages of the Six Sigma DMAIC methodology.

Control Plan

After the changes had been put in place and were part of the ED process for a month, a control plan was formulated in April, 2004 to assign controls for the inputs which had been identified as high priority from the C & E chart and the FMEA. The process step in which the input was seen was identified, and the inputs and outputs for the steps were noted. The target time for the process was decided and the actions to be taken to keep the step in control were identified along with the person(s) responsible for monitoring the item. The next column in the control plan noted the current control method followed by the sample size and sample frequency and then the reaction plan in case it was noticed that the process was slipping back to a lower performance level. The idea of the control plan is to make a note of what needs to be monitored, and to make sure the changes which have been put into place are effective over a long period of time. By monitoring the so called "trouble" areas and keeping them in check, it is hoped that there will be a sustainable improvement in the system. Not only should the changes stay in place and not revert back to the point where the project started, but also continuous efforts need to be made to make sure that the staff looks for areas in which improvements can be made. After identifying new areas, the same process can be implemented to make changes in these areas and thus make the operation even more efficient.

Financial Data

Financial data were collected from the records in the hospital, of the charges for each patient who enters the ED. These levels of charges depend upon the level of service received by the patient in the ED. The charges were calculated from the ED service level calculation sheet given in Appendix C. According to the procedures done on patients, the points were added to determine the level of charges.

The charges were of the following types:

ER level 1 triage only,

ER level 2 follow up,

ER service level 1 (No points assigned),

ER service level 2 (1-2 points),

ER service level 3 (3-6 points),

ER service level 4 (7-10 points),

ER service level 5 (11+ points), and

ER service level 6 - Critical Care.

Power Analysis and the Risk of Type I Error

A power analysis was employed to determine the correct sample size to check the efficacy of Six Sigma improvements. The power analysis was performed manually. The statistical analysis used an alpha level of 0.05.

Data Collection

Data were collected in three ways. Data from the ED log book was collected for October 2003 and October 2004 which served as summary data for these two months. The data included the following information:

- Date of entry,
- Time the patient entered the ED,
- Time the patient entered the ED bed,
- Time the patient was discharged or admitted to the hospital,
- The triage (acuity level),
- How the patient arrived - by EMS, a personally owned vehicle, or by law enforcement,
- Age,
- Gender,

- Hospital account number,
- Name of the treating physician,
- Who treated the patient,
- Was the patient admitted to Minor Emergency Care section of the ED,
- Did the patient expire,
- Did the patient leave without being seen (LWBS) or against medical advise (AMA), and
- Did the length of stay take more than six hours?

The data allowed researchers to calculate information and to measure three segments in the patients' length of stay: the length of time it took the patient to make it to the ED bed, the length of time from the ED bed to discharge or admission, and the total length of stay. In addition to the ED log information, direct observations were also taken in the months of December 2003 – January 2004 and September – October 2004 to obtain a representative sample of the ED patients. A proportionally stratified random sample of patients was collected to include an appropriate number of the MEC and non-MEC patients. One patient was followed in a three hour time slot during any given day. The observers selected the time slot previously determined from the sampling plan, and collected information on the time spent by the patients in each station of the process. The direct observations were designed to measure the finer details, such as the frequency and duration of the visits by the nurses, doctors, radiology technicians, respiratory therapists, laboratory technicians and registration personnel.

The observers used a standard data collection sheet and stop watches to record all the time information. The patients were observed from the point of entry to exit (discharge, admission or transfer). Special causes of variation or remarks were noted on the spreadsheet. The data were tabulated and analyzed using SPSS version 12.0 software.

Independent t-tests were used to look for differences between Length-of-Stay (LOS) as seen in the direct observations collected during December 2003-January 2004 and September 2004-October 2004. The total LOS, time from Triage to the ED bed and time from the ED bed to discharge were analyzed. Independent t-test was also used to look for differences in LOS between the MEC and the non-MEC patients. Financial data were analyzed by using the independent t-tests to look for differences in average earnings between October 2003 (start of the project), April 2004 (one month after the changes had been in place) and August 2004 (six month after the changes had been in place).

It was important to have a convincing reason to implement the project to reduce wait times in the ED. The leaders of the hospital needed to know why the changes should be brought about in the ED processes. How would the hospital benefit if the project was undertaken? The value proposition was put forward where it was discussed that the business opportunity was real, where the hospital could win and it was worth doing. The general rule applied was that the improved process should bring about a 5% increase in the patient load, and would result in $450,000 additional revenue. The customers would get better service, the employees would enjoy a better work environment, and the process change would add to a healthy community. The goals were set at reduction of variation in total wait time by 5%, reduction in mean wait time by 10%, and reduction in the number of patients leaving without being seen, against medical advice or staying more than 6 hours in the Emergency department.

Potential decreases in the wait time and increases in revenue were visualized to answer the earlier identified Voice of the Customer and Voice of the Business. These tools require involvement of the employees of the hospital at all levels, not only to help in mapping the process, but also in suggesting failure modes and improvements.

It was found that at the time the project was started, the hospital was in the 4th percentile for patient satisfaction as measured by Gallup Poll surveys, among other hospitals surveyed. This was unacceptable and alarming to the hospital as it meant that 96% of potential competitors were better in serving ED patients. Their goal was to reach the 80th percentile in customer satisfaction. Among many sub categories for dissatisfaction on the Gallup poll, CTMC's patients identified ED waiting time as the highest dissatisfier. They continued to measure patient satisfaction and they found that the satisfaction scores have increased steadily over the last few months. Thus the objective of this study was to analyze the Emergency Department processes, identify where and why the patients are waiting for service, and ultimately to decrease patient Length-of-Stay (LOS) and to tie this together with patient satisfaction scores and financial gains in terms of increased patient load and revenue, along with cost savings.

Analysis Phase

Other hospitals in the neighboring areas were visited on November 24, 2003, and their Emergency Department procedures were studied and compared with that of CTMC. These visits provided valuable insight into the changes that could be made to improve the processes (Appendix A).

FIGURE 3: SIPOC Process Map

SIPOC Process Map

Inputs	Process	Outputs
1 Patient 2 Nurse 3 Signage/layout 4 EMS/modes 5 Equipment/Supplies	Patient Presents to Triage 1 Triage captures complaint and time 2.Vital Signs captured 3 Basic treatment 4 Decision on next step	1 Patient to Registration 2 Chart (inlcudes protocol) 3 Basic treatment → High Acuity patients go directly from Triage to ER
1 Patient to registration 2 Chart 3 Outside stimuli (phone calls,visitors, family)	Patient presents to Registration 1 Registration clerk enters patient into the system 2 Checks insurance/method of payment 3 Patient signs NPP/ given patient rights 4 Patient given wristband 5 Patient sent to waiting room	1 Patient to lobby 2 Account number 3 Chart to ER 4 Insurance Info 5 Privacy practices form (HIPAA) 6 Labels 7 Armband
1 Patient to ER bed 2 Nurse 3 Labels 4 Chart 5 Family members/friends	Management 1 Nurse picks up the chart 2 Initial assessment by primary nurse 3 Initiate care (blood draw/IV) 4 Complete chart/communication 5 Chart to "Dr to-be seen" rack	1 Diagnostic orders 2 Patient prepared for physician (comfort control) 3 Possibly early diagnostics 4.Verbal instruction to MD 5.Ancillary services notification 6 Patient communication
1 Doctor contact 2 Diagnostic results 3 Equipment 4 Materials 5 Personnel 6 Old charts 7 Code Teams(if needed)	Treatment 1.Doctor visits patient 2 Meds ordered 3 Labs, diagnostics ordered 4 Results received 5 Reassessment	1 Doctors orders 2 Continued tests/labs 3 Nurse treatment 4.Transport to radiology 5 Transport to GI lab family/friends 7.Pharmacy
1 Doctor's orders 2 EMS/Critical Air 3 Nurses and ER techs	Disposition 1 Desicion/care completed 2 Transportation arranged 3 Patient moved 4 Chart completed 5 Charges entered 6 Room cleaned	1 Patient instructions 2 Doctor dictations 3 Prescriptions 4 Transfer to another hospital 5 Patient discharge/morgue 6.Patient admitted to hospital/ER

FIGURE 4: Cause and Effect Matrix

		Rating of Importance to Customer	10	6	8		Rating
			Quality Care	Error Reduction	Speed of Service	Total	
	Process Step	**Process Input**					
1	Patient Presents to Triage	Patient	3	0	9	102	
2		Nurse	9	3	1	116	
3		Signage/Layout	3	1	9	108	
4		EMS - Modes of Entry	0	0	3	24	
5		**Equipment and Supplies**	**9**	**9**	**9**	**216**	**1st priority**
6	Patient Presents to Registration	Patient	0	9	3	78	
7		**Chart**	**9**	**9**	**9**	**216**	**1st priority**
8		Outside Stimuli	9	0	3	114	
9	Management	Patient to ER Bed	1	1	9	88	
10		Nurse	3	1	9	108	
11		Labels	3	9	3	108	
12		**Chart**	**3**	**3**	**9**	**120**	**3rd priority**
13		Family and Friends	3	0	9	102	
14	Treatment	Doctor Contact	3	0	9	102	
15		**Diagnostic Results**	**9**	**9**	**9**	**216**	**1st priority**
16		Equipment	3	3	3	72	
17		**Materials**	**9**	**9**	**9**	**216**	**1st priority**
18		**Personnel**	**9**	**3**	**9**	**180**	**2nd priority**
19		Code Teams	1	1	3	40	
20	Disposition	Doctor's Orders	3	1	9	108	
21		EMS/Critical Air	3	1	9	108	
22		Nurses/ER Tech	3	1	9	108	
23		Doctor Communication	**9**	**1**	**3**	**120**	**3rd priority**

FIGURE 5: Failure Modes and Effects Analysis

Failure Modes and Effects Analysis (FMEA)

Process Step	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN
Equipment and Supplies	Cannot find moblie equipment i e IV pump	Delay in service	10	Did not clean after use			0	0
				Has not been returned after a transfer fromother floors			0	0
	Supply Shortages	Delay in service	10	Unorganized reordering process			0	0
				ER staff unsure of where inventory is located				0
				Multiple people reordering				0
			10	Materials misplaces the order	3	Material dept downloads the reodrder sheets	1	30
			10	Speed of receiving supplies	1	Currently have a 24 hour turnaround on receiving	1	10
			10	Speed of preparing supplies	2	Currently use visual indicators	1	20
Computer Systems	Expected computer downtime	Must revert to manual processes	4	Manual processes must be followed	3			0
				Personnel must update computer once it's online	3			0
		Delay in process	10	Registration mislabeling on chart	3	Meet with registration staff if problem arises	8	240
		Quality suffers	10	ER mislabels the specimens	3			0
		Delay in process	10	ER rushing/busy	3			0
		Delay in process	3	ER rushing/busy	3			0
				Miscommunication	4			0
		Delay in process	4	Lack of experienced phlebotomist	4	No control	10	160
		Delay in process	3	ER miscommunication	4	No control	10	360
		Delay in process	10	Inclement weather	3	Preventive maintenance	10	300
		Delay in process	3	Lack of experienced phlebotomist	5	No control	10	450
		Delay in process	10	Lack of abilities	0	Helping and coaching	1	0
				Lack of training	0			0
		Delay in process	8	Large events/ accidents	3	Lab staffing is increased	7	168
		Delay in process						0
		Delay in process		Personnel issues-CT tech not answering pager				0
		Delay in process		Old Apple product, only 1 person that can work on it		No control	10	0
		Delay in process	10	Communication breakdown	8	No control	10	800

Improvement Phase

The FMEA identified the main inputs, and recommendations for those inputs led to the initiation of the improvement phase. The hospital implemented a few significant changes under the guidance of the Six Sigma team. The Triage and Registration areas were redesigned. The new process helped ensure that patients were directed towards the Triage window which would be the first step for the patient. Earlier, the patient would sometimes mistakenly go to the registration window and end up wasting time traveling from one window to the other. The registration window was walled off to avoid this confusion and time waste.

A further improvement will be bedside registration, thus saving time between arrival of the patient and allotment of the bed to the patient. This process change awaits the acquisition of appropriate mobile computer hardware.

The decision to move the patient to the ED bed was put into the hands of the Triage nurse who would know when a bed in the ED was vacant. Having the Triage nurse place patients in ED beds decreased length of stay for patients. ED nurses earlier, would pick up a chart for waiting patients, come out to the waiting area and pull the patient back to the ED bed. Having the Triage nurse put the patient in the bed, "pushed" patients into the ED. This changed the process from a staff focused process to a patient focused process.

The hospital also decided to restructure the Triage room into 2 areas. One area would be used to capture the patients' chief complaints and medical history and the other area would be used to record the vital signs of the patient thus making patient flow quick and smooth. Also, the second room has the capacity to be used as a second Triage room in case of peak demand.

Another important improvement was to organize the equipment and supplies in the supply room so that the supplies were easy to locate and thus save time for all ED staff.

A new information technology in the form of Picture Archiving and Communication Systems (PACS) was also added to the hospital which has reduced the time taken for transfer and reading of images like X-Ray , CT and MRI by converting them into digital pictures and making them available through the hospital computer network.

Control Phase

Once the changes had been implemented for 6 months, an evaluation of the ED processes was repeated. The FMEA was reviewed and the RPN calculated again to check for improvement. This provided an insight into the areas which needed to be worked on further and also showed if the changes have been effective. The control plan shows the areas which were improved (chart, equipment and supplies etc). It also shows the input and output for each step and what the target time for completion of reach step would be. The control plan also assigns responsibility to a particular person in the team who is responsible for keeping track of that step (ED clerk, Triage nurse). The control measures are also recommended to make sure that the time for each step stays within the stipulated target time by exercising the specific controls, and what actions should be taken in case the process slips back to the prior state (Appendix C).

As seen in the Control Phase summary, the process improvements that have been put in place have to be continuously monitored and evaluated. Each of the identified problem areas was looked at from time-to-time to make sure the process does not slip back to the prior state. The control plan summarized the areas which need to be monitored, who was responsible for monitoring each area and also what should be done in case the area was not showing sustained improvement. The charts are monitored by the Triage nurse from the Triage to ED bed and by the ED clerk while the patient is in the ED bed. If the time taken for each process begins taking more than the target time, one week of patients will be observed and data collected on the time taken for the process. The reason for the delay is identified and corrected and a note made in a record keeping system.

Similarly, the number of patients leaving without being seen is monitored and captured. If the numbers increase, the reasons for the increase is looked into to make sure it is not due to increase in wait time. Other indicators like patient satisfaction survey scores and total Length-of-Stay data are also be monitored regularly. This will help to keep track of the patient wait time and to make sure the target wait time is not exceeded.

The revenue earned by the ED is monitored to calculate any change in earnings. Any decrease in the trend would be an indicator that the process needs to be looked at again to ensure it is not going back to the state before the improvements.

CHAPTER IV

RESULTS /ANALYSIS:

The SIPOC map created in October 2003 summarized the basic processes as: 1) patient presents to Triage, 2) registration, 3) treatment, 4) management of the case, and 5) disposition of the patient. These five steps formed the basis of the subsequent steps. This is shown in Figure 3.

The Cause and Effect (C& E) matrix, shown in Figure 4, showed that the first priority should be the equipment and supplies in the first step (patient presenting to Triage), chart in the second step (registration), and diagnostic results and treatment in the fourth step (treatment and management). These process inputs had the highest total scores of 216 each, and were thus considered more important than the other inputs.

A total of six inputs were identified as those which needed to be focused on in the FMEA. These were: 1) equipment and supplies, 2) chart, 3) diagnostic results (both lab and radiology), 4) materials, 5) personnel, and 6) doctor communication.

The FMEA showed the quantified list of defects. The targets of the improvement process were those with the largest RPN, as shown in the figure 5.

Some members of the project team also visited neighboring hospitals to observe the functioning of the ED in those hospitals to generate ideas for the improvement team. The observations are noted in the Appendix A.

These tools were then used to make improvements in the ED to change the processes to a faster and more efficient system which would result in greater satisfaction for the patients and increase revenue. The Triage and Registration areas have been redesigned to direct the patient towards the Triage window first instead of wasting time by coming to the Registration and then being directed to Triage. The ED personnel now also strive to get the patient into and ED bed as soon as possible. The front end of the process was reworked to reduce this time and reduce the frequency of errors in the patient queuing process. Previously the admission of the patient in the ED area was not controlled by any one person and resulted in confusion over the order in which the patients were called in. The registration personnel are now told to return the chart to the Triage area after registration which decreased the time they spent in taking the chart into the ED. Also the Triage nurse is now responsible for calling the patient back in the order they presented to the Triage unless a more serious condition warrants a change in order.

The charts were delivered to the MEC area by the registration personnel which makes the MEC area independent of the remainder of the ED, where the more serious cases are seen. The supply cabinet was also re-organized, making it easier to locate the supplies needed.

The hospital also acquired a new PACS system to reduce the time for radiology and thus manage each case needing radiology investigations faster.

Power Analysis was performed to determine an appropriate sample size for data collection. Using $\alpha = 0.05$ and $\beta = 0.20$, with the given standard deviations and the means for the earnings of the respective months to be analyzed. The sample size (N) required was determined to be 369 in each group, if a 10% difference in means was to be looked for. The required sample size was 1475 if a 5% difference in means was the desired effect size. The data was available for N= 2393 cases in October 2003, N = 2262 cases for April 2004 and N = 2432 cases for August 2004.

When comparing the Length-of-Stay (LOS) between the original ED and the ED with improvements, it was seen that there was a significant difference in the length of stay – from Triage to ER bed when compared between the October 2003 (M = 38.78 minutes, SD = 29.13 minutes) and the April 2004 LOS (M = 19.18 minutes, SD = 10.21 minutes), t (df = 2186) = 7.31, p <0.01, two tailed. Notably the new process reduced the variation in wait time as seen from table 1. The mean time from Triage to ED bed was reduced by half and the variation was reduced to almost a third of the original variation in time (Roberts, 2004).

TABLE 1: Comparison of Length-of-Stay between October 2003 and April 2004

	Mean (minutes)	Standard deviation	df	t	p
Length of Stay - Triage to ER bed					
October-03	38.78	29.13			
April-04	19 18	10.21	2186	7.31	<0.01
Total Length of Stay					
October-03	137.87	81.78			
April-04	107.14	68.21	2303	4.02	<0.001

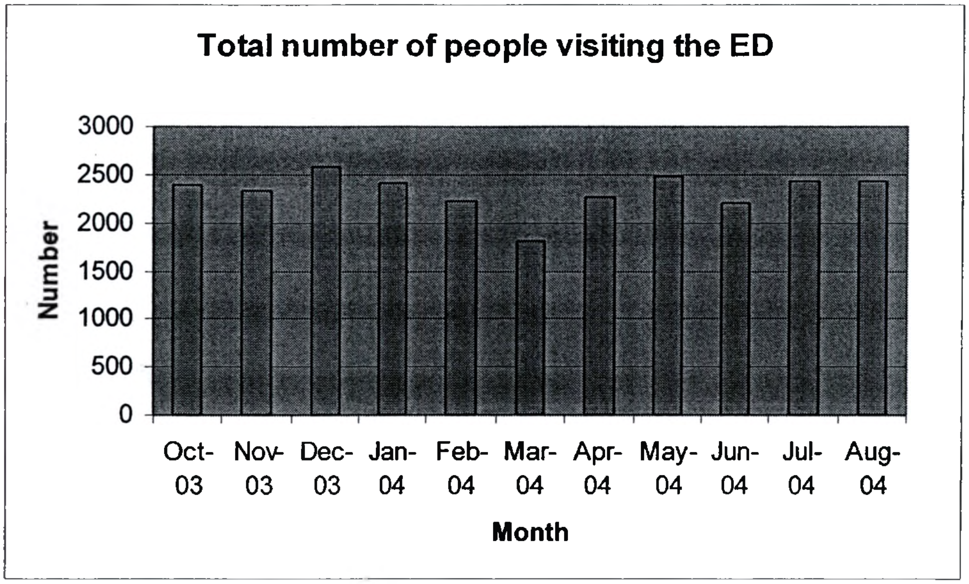
An analysis of the total Length-of-Stay showed the same effect. An independent t-test showed that there was a significant difference in the LOS of the October (M =137.87 minutes, SD= 81.78 minutes) and the April (M =107.14 minutes, SD= 68.21 minutes), t (df = 2303) = 4.02, p<0.001, two tailed. The mean time in the ED bed was reduced by more than 20% and the variation in the time was reduced by more than 15 %. Thus the variation in waiting time for the patient was being reduced dramatically which lead to the reduction in mean Length-of-Stay (Roberts, 2004).

As the project moved forward and as outside members of the team became less involved in the continuing monitoring, the hospital staff were encouraged to keep meeting once a month and to explore new avenues of improvement in the ED and reduce waiting times even more. The hospital has presented this project in conferences and to the leaders of the Adventist Health System and plans to train its own personnel in Six Sigma. These ED staff will be responsible for carrying this project forward and also to begin new projects in other departments.

Usually when the outside team withdraws, there is a chance of the process returning to the old format and the quick improvements which were seen may revert back to what it was before the project started.

Thus, there was a need to put a control plan in place to ensure continuous monitoring of the processes and a person who is accountable for each process or sub-process. Also it is important to keep in place the reaction of the team in case the current control method seems to fail. It was determined that if there was a delay seen in admission of patients to the ED bed, it would be important to understand why the delay happened. This is to be monitored by the ER clerk. The unnecessary phone calls to the ER clerk need to be reduced and the phone system needs to be examined to avoid time waste. There is also an emphasis on decreasing the lab turnaround time and monitoring the number of patients each month who leave without being seen.

FIGURE 6: Total Number of People Visiting the ED Per Month



Since there is no recognizable trend in the total number of patient visits, according to season, as seen from figure 6, it can be assumed that a seasonal trend had nothing to do with the number of patients visiting the ED during October 2003 to August 2004. Any increase in the number of patients could be attributed to the quicker service and increased patient satisfaction and less patients leaving the ED without being seen.

The analysis of data collected by direct observations showed that there was a significant decrease in waiting time after one month of the changes being in place and this improvement continued to be seen even after six months of the changes. The difference in Length-of-Stay was seen in 1) the total Length-of-Stay, 2) the time from triage to ER bed and 3) from ER bed to discharge or admission. The total LOS had decreased by more than 30%, from an average of 159.39 minutes in Dec. 03- Jan. 04 to 110.45 minutes in Sep. 04 – Oct 04. The standard deviation also showed a decrease from 95.31 minutes to 54.37 minutes, showing a 40% decrease in variation for the Length-of-

Stay. There was a significant decrease in LOS between the two groups of observations (t (df =126) =3.609, p<0.001, two tailed).

As seen from table 2 and figure 7, there was also a significant decrease in the time taken from the Triage to the ED bed between Dec 03-Jan 04 (M= 42.02 minutes, SD = 27.66 minutes) and Sep 04- Oct 04 (M= 32.09 minutes, SD = 14.54 minutes) observations (p<0.05). The mean time had decreased by more than 20 % and the variation had decreased by more than 45%.

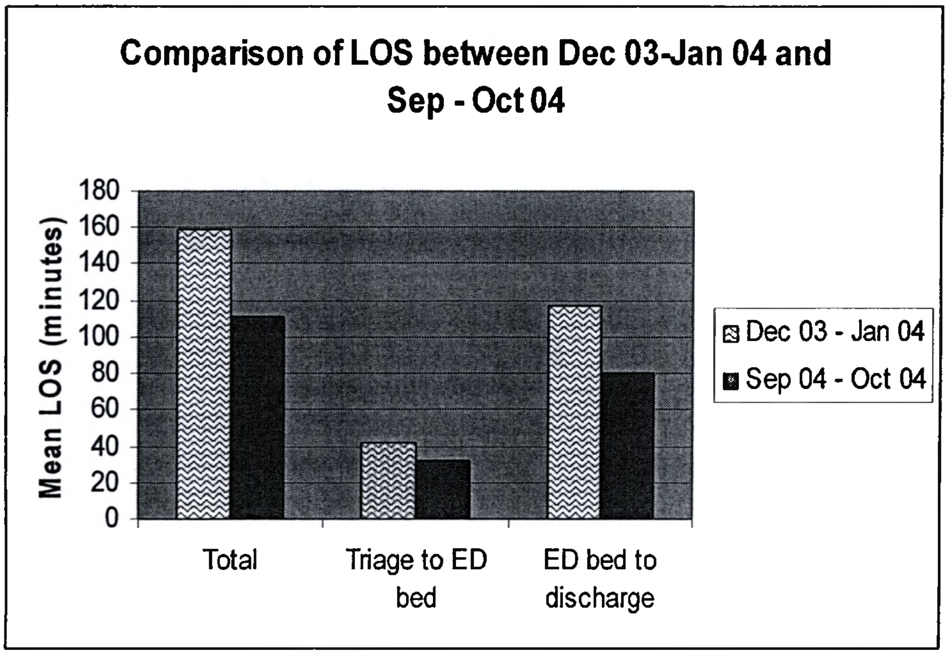
TABLE 2: Difference in Length-of-Stay

Length of Stay (LOS)							
		N	Mean (minutes)	Standard Deviation	df	t	p
LOS total							
	Dec 03 - Jan 04	61	159.39	95.31			
	Sep 04 - Oct 04	67	110.45	54.37	126	3.609	<0.001
LOS- Triage to ED bed							
	Dec 03 - Jan 04	61	42.02	27.66			
	Sep 04 - Oct 04	67	32.09	14.54	126	2.573	<0.05
LOS- ED bed to Discharge/ Admit							
	Dec 03 - Jan 04	61	117.38	88.98			
	Sep 04 - Oct 04	67	79.84	53.52	126	2.922	<0.01

A more significant difference (t (df =126) = 2.573, p<0.001, two tailed) was seen in the LOS after the patient is called into the ED. The average Length-of-Stay from the time the patient is called into the ED till discharge or admission decreased from 117.38

minutes in Dec 03-Jan 04 observations to 79.84 minutes in Sep 04- Oct 04. The variation in Length-of-Stay also decreased when the two groups of observations were compared (Dec 03-Jan 04 SD = 88.98 minutes, Sep 04 – Oct 04 SD = 53.53 minutes).

FIGURE 7: Comparison of Length-of-Stay in the ED

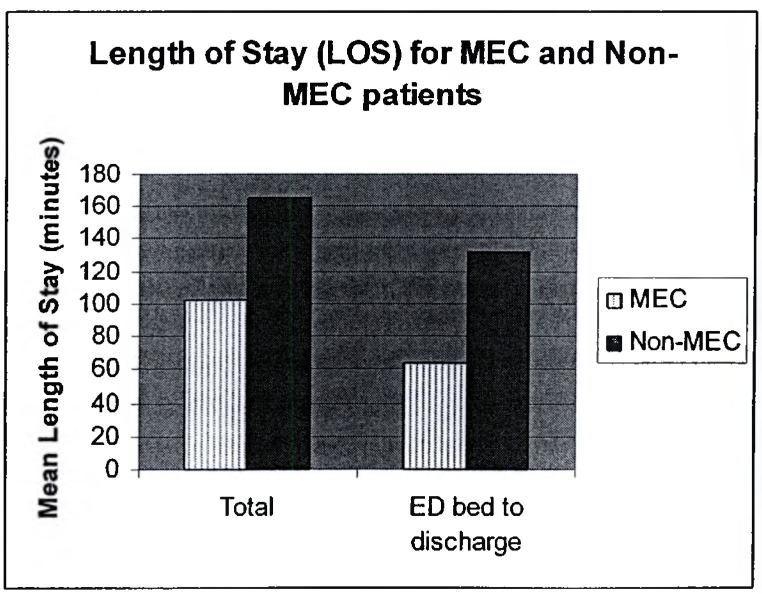


Between the MEC and the non-MEC patients, the difference was seen in the time that the patient was in the ED bed and not in the process before the patient reached the ED bed. There was a significant difference in the total Length-of-Stay between the MEC and the non-MEC patients (t (df = 124) = 4.887, p<0.001, two tailed), and the Length-of-Stay from the ED bed to discharge (t (df =124) = 2.586, p<0.001, two tailed). This is shown in table 3 and figure 8.

TABLE 3: Comparison of Length-of-Stay (LOS) between MEC and Non-MEC Patients

Comparison of LOS between MEC and non- MEC patients							
		N	Mean	Standard Deviation	df	t	p
LOS total							
	MEC	69	102.78	41.18			
	Non-MEC	57	165.51	96.58	124	4.887	<0.001
LOS- Triage to ED bed							
	MEC	69	38.13	21.26			
	Non-MEC	57	35.96	23.62	124	0.541	>0.05
LOS- ED bed to Discharge/ Admit							
	MEC	69	64.65	37.17			
	Non-MEC	57	131.48	85.14	124	5.862	<0.001

FIGURE 8: Comparison of Length-of-Stay between MEC and Non- MEC Patients



As seen from table 4, when the LOS was compared for the patients visiting the MEC area at the start of the project and after six months of implementation of changes, there was no significant difference seen in the Length-of-Stay between Triage and ED bed (t (df = 67) = 0.848, p>0.05, two tailed), ED bed to discharge(t (df = 67) = 1.034, p>0.05, two tailed), or in the total LOS in the ED (t (df = 67) = 1.38, p>0.05, two tailed).

TABLE 4: Difference in Length-of-Stay (LOS) for MEC Patients.

	N	Mean (Minutes)	Standard deviation	df	t	p
LOS - Triage to ED bed						
Dec 03 - Jan 04	32	40.47	25.53			
Sep 04 - Oct 04	37	36.11	16.83	67	0.848	>0.05
LOS - ED bed to discharge / admit						
Dec 03 - Jan 04	32	69.63	36.84			
Sep 04 - Oct 04	37	60.35	35.62	67	1.034	>0.05
LOS - Total						
Dec 03 - Jan 04	32	110.09	41.84			
Sep 04 - Oct 04	37	96.46	40.09	67	1.38	>0.05

This was expected as the MEC is typically a “fast track” area designed to serve non-emergency cases with quick care.

In case of the non-MEC patients, a significant difference was seen in the mean LOS before and after the changes. A significant difference was seen in the time spent from Triage to ED bed (t (df = 55) = 3.213, p<0.01, two tailed), time in the ED bed to discharge (t (df = 55) = 2.703, p<0.01, two tailed), and total LOS(t (df = 67) = 3.396, p<0.01, two tailed). The mean time for total LOS decreased from 207.52 minutes to 127.70 minutes, and the variation in total LOS was reduced from 109.33 minutes to 64.62

minutes. The reduction in mean LOS from Triage to ED bed was from 45.78 minutes to 27.13 minutes, with a decrease in standard deviation from 30.30 minutes to 9.168 minutes. The mean time spent in the ED bed till discharge was reduced from 161.74 minutes to 103.87 minutes, with a decrease in variation from 97.34 minutes to 62.14 minutes. This is shown in table 5 and figure 9.

FIGURE 9: Difference in LOS of Non-MEC Patients

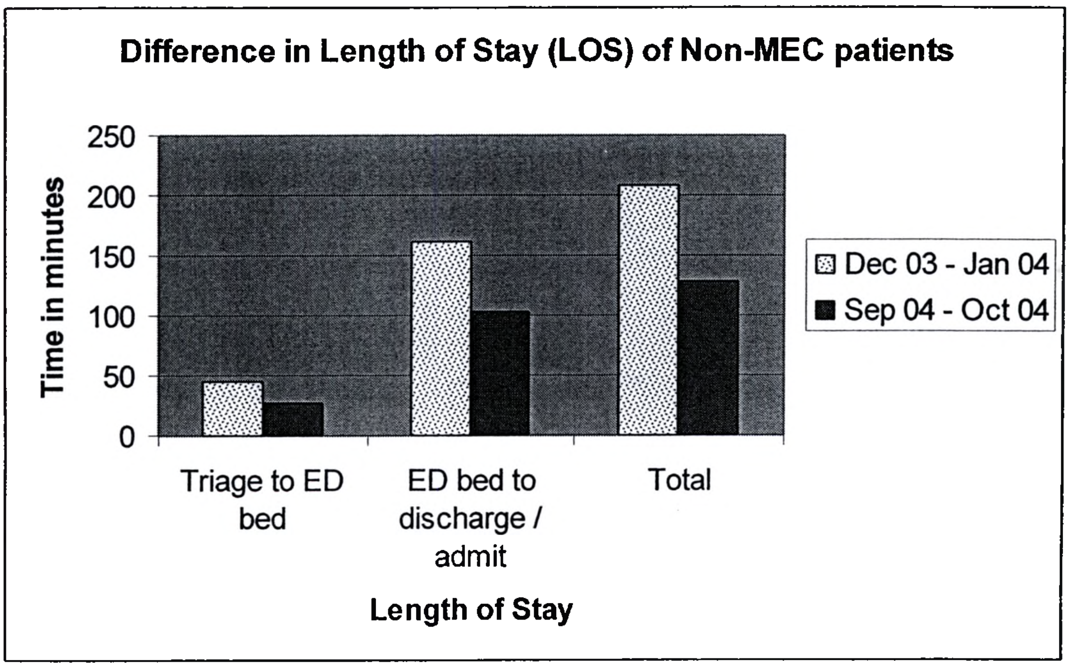
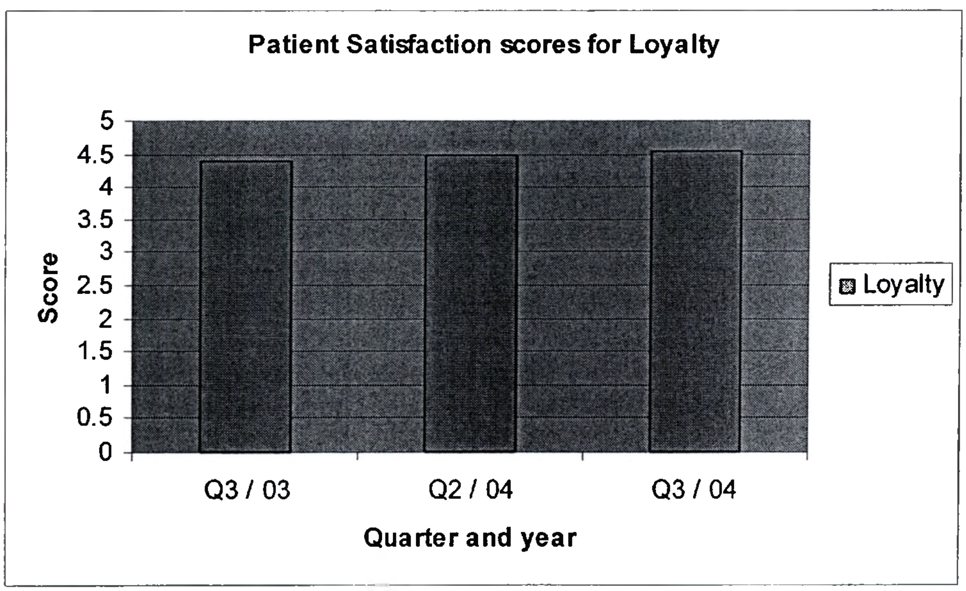


TABLE 5: Difference in LOS for the Non-MEC Patients

	N	Mean (Minutes)	Standard deviation	df	t	p
LOS - Triage to ED bed						
Dec 03 - Jan 04	27	45.78	30.3			
Sep 04 - Oct 04	30	27.13	9.16	55	3.213	<0.01
LOS - ED bed to discharge / admit						
Dec 03 - Jan 04	27	161.74	97.34			
Sep 04 - Oct 04	30	103.87	62.14	55	2.703	<0.01
LOS - Total						
Dec 03 - Jan 04	27	207.52	109.33			
Sep 04 - Oct 04	30	127.7	64.62	55	3.396	<0.01

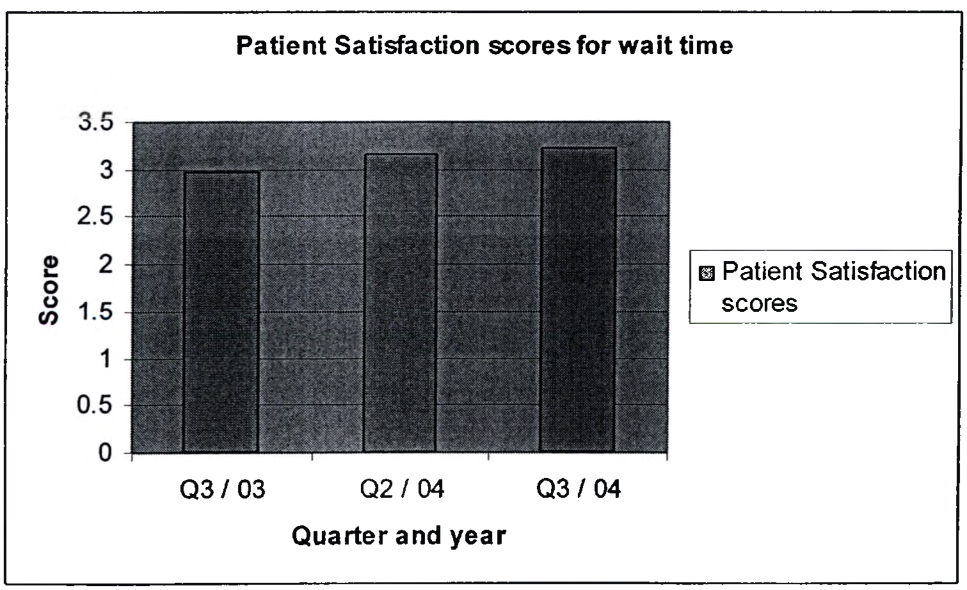
The decreased length of stay in the ED, is reflected in the increased patient satisfaction ratings for the months after the changes had been brought about and also in the increased revenue that the hospital generated due to improved and faster processes, as seen in figures 10 and 11.

FIGURE 10: Patient Satisfaction Scores for Loyalty



The Gallup Poll results were obtained from the hospital and compared for the different areas in which the patients were questioned. The scores obtained were from Q3 2002 to Q3 2004. The satisfaction scores from Q3 2002 (July – September 2002) to Q3 2004 (July – September 2004) showed a range of mean scores from 2.97 to 4.407 for the different questions. The waiting time showed the lowest mean score (2.97), with the highest score being for loyalty to the hospital (patient will come back to the hospital again for treatment) (4.40). By Q2 2004 (January- March 2004) and Q3 2004 (July-September 2004), the respective scores were 3.16 and 3.23, showing an improvement in the Gallup scores for wait time in the ED. This indicates a higher patient satisfaction with the processes in the ED, especially with regard to the wait time. These are shown in the chart below.

FIGURE 11: Patient Satisfaction Scores for Wait Time



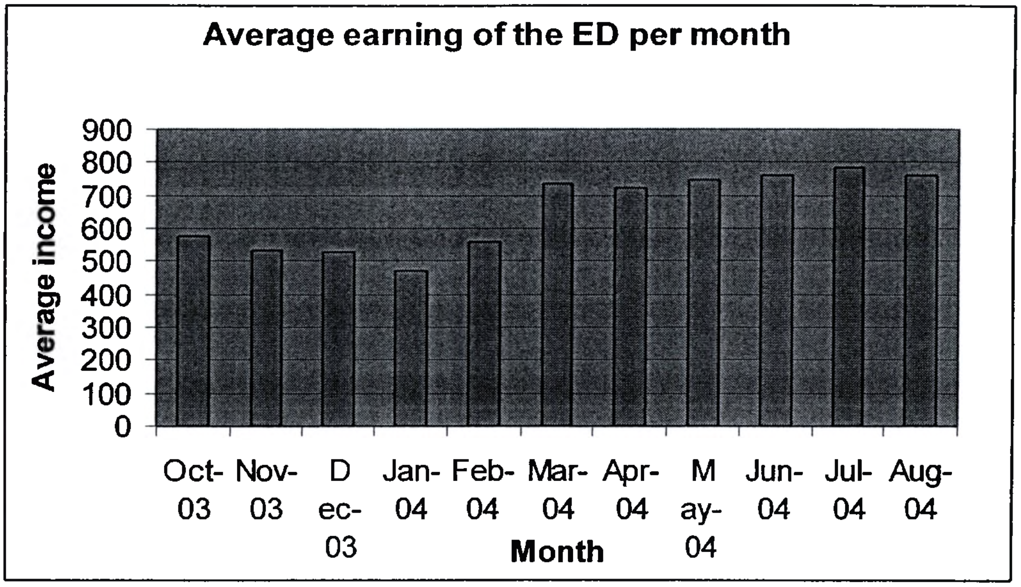
The hospital had an increase in monthly earnings of $250,212 from October 2003 (when the project was started) to April 2004 (when the changes had been in place for a month). The monthly revenue showed an increase of $461,633 between the months of October 2003 and August 2004 (when the changes were in place for six months). Also, it was seen that due to the improved process after the changes had been in place for six months, there was a steady rate of increase in revenue as seen from the fact that there was an increase in the monthly earnings in August 2004 as compared to April 2004 ($ 211,421).

The average earnings per month per patient in the ED are given in table 6 and shown in Figure 12. It was seen that the average earning per patient in the ED increased from $ 576.00 in October 2003 to $ 758.02 in August 2004. This could be because of increased patient load, fewer patients leaving without being seen and more care given to the patient.

TABLE 6: Average Earning Per Patient in ED Per Month

Month	Average earning per patient in ED
October-03	576.00
November-03	529.89
December-03	528.65
January-04	471.67
February-04	556.08
March-04	733.88
April-04	719.97
May-04	748.20
June-04	758.02
July-04	782.93
August-04	756.58

FIGURE 12: Average Earning of the ED Per Month

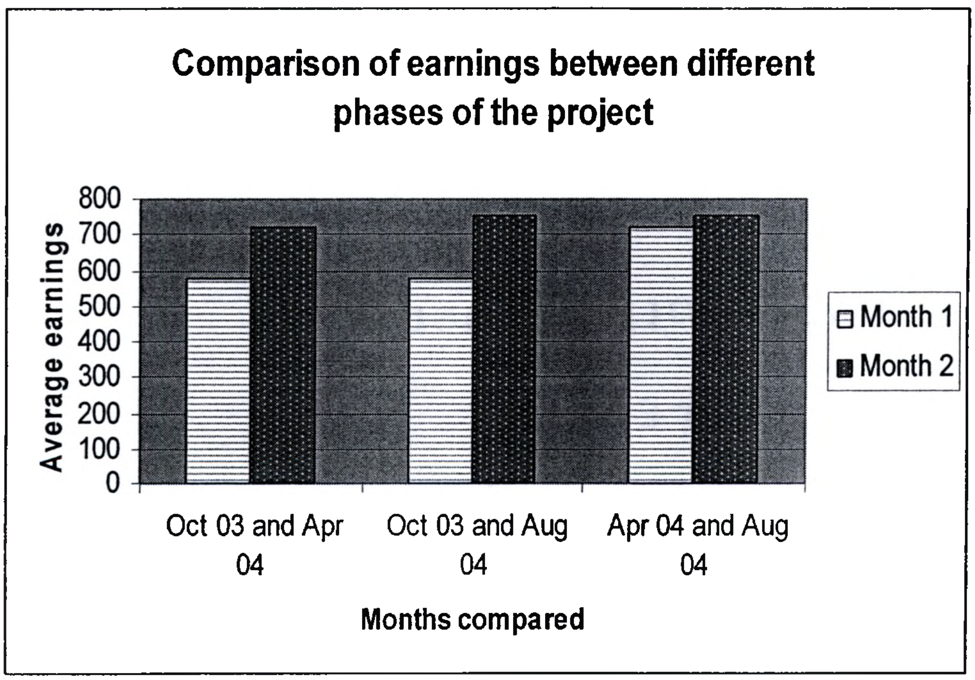


There was a significant difference in the earnings per patient in the ED when a t-test was run between the earnings for the ED at the beginning of the project (October 2003) and after the improvements had been in place for one month (April 2004) (t (df = 4653) =11.315, $p<0.001$, two tailed). There was also a significant difference between the earnings at the start of the project and after the changes had been in place for six months (August 2004) (t (df = 4823) =13.762, $p<0.001$, two tailed). There was also a difference seen in the earnings per patient between April 2004 and August 2004 (t (df = 4692) =2.379, $p<0.05$, two tailed), suggesting that the changes were effective and were being maintained to improve the process continuously. These findings are summarized in table 7 and figure 13.

TABLE 7: Difference in Total Charges Earned by the ED Per Patient

Total Charge						
	N	Mean	Standard Deviation	df	t	p
Oct-03	2393	576.00	346.82	4653	11.315	<0.001
Apr-04	2262	719.97	510.08			
Oct-03	2393	576.00	346.82	4823	13.762	<0.001
Aug-04	2432	756.58	541.92			
Apr-04	2262	719.97	510.08	4692	2.379	<0.05
Aug-04	2432	756.58	541.92			

FIGURE 13: Comparison of Earnings in the Different Phases of the Project



CHAPTER 5

CONCLUSION

At the conclusion of this study it was seen that:

1. This study was successful in introducing the tools of industrial engineering in healthcare and using these tools to improve processes and increase customer satisfaction. The faster a patient can get through the process, the more satisfied they will be and this will reflect in increased revenue, better reputation, and increased patient load for the hospital.
2. As seen in this study, the wait time for patients was significantly decreased and this improvement was sustained in the system six months after the changes had been in place.
3. Even after outside help had been withdrawn the changes were kept in place by the hospital staff and monitored to make sure there was continuous improvement in the processes. This was also seen from a decreased variation in Length-of-Stay by more than 15%.
4. The patient satisfaction scores improved and the hospital showed increased revenue after the project.

5. The revenue generated per month per patient on an average increased from $576 in October 2003 to $756 in August 2004, because of the changes implemented.
6. It was seen that the investment in such a project could definitely bring about a long term increase in savings and gains.

The idea behind using Six Sigma is to incorporate a quality focus into the culture of the hospital and to encourage people to look for areas where improvements can be made to provide quick and efficient care to the patient.

One of the difficulties in measuring the impact of quality improvement in healthcare is in calculating the cost savings or increased revenue. Many do not have a fixed cost attached to them like care given by a nurse to an extremely sick patient. In this study, the increased revenue was calculated only on the basis of the increase seen in charges collected from patient visits. An increase was due, in part, to the improved quality reputation of the hospital. Since there are so many human factors involved, it is not easy to say if this study will yield similar or better results in another setting.

Some of the points which were noted and may cause variation in the healthcare setting include:

- Patient might lose their turn if they are away from the waiting area when their name is called by the Triage nurse. They might be in the rest room or the vending machine area and may not answer to the nurse who will then call the next name on the list,

- When there is shortage of staff, the Triage nurse has to help in the back. The nurse may be busy in the back when the patient comes in the waiting area and may have to wait for the triage nurse to be free to see them,
- A patient might know an employee of the hospital and may be taken to the back faster and may get faster care,
- Time may be spent to get a wheelchair for the patient or to check with Medicaid about the insurance status of the patient,
- Patients may take more time to move if they are on crutches or on a wheelchair,
- For Medico-Legal cases, patients may have to wait for the police to show up before any non-emergency care is given to them,
- Sometimes patients are taken to radiology from the waiting area if the triage nurse decides they will need an X-ray. This saves time in the ED, but is not regular finding,
- Patient may be taken for Radiology and returned for some reason like suspected pregnancy (have to rule out pregnancy and then take them to radiology again),which wastes time for two trips,
- If the X ray is done at the bedside, no time is lost in taking the patient to radiology and back,
- Some mothers bring sick siblings or sometimes the mother and the children are all sick. They all come together and see the doctor together: Should it be counted as one case or separate cases? It shows up as less time if counted as separate cases, more time if counted as one case,

- Sometimes when the mother and child are both patients, the technician that checks the vitals may have to go back in to the ED bed, if they forget to take the vitals of both, thus resulting in more time to carry out the same task,
- The patient might leave due to financial reasons: they may not be able to pay and will leave without being seen, even though they have been through part of the process,
- Time may be spent by the patient after discharge when they need to pay cash or use some other uncommon form of payment,
- Different acuity level charts (high acuity) do not exist any more, only MEC and non-MEC, non-urgent charts are given to the non-critical cases. Other patients with life-threatening problems are taken care of immediately,
- Human factors - some patients have more questions or are more chatty, spending more time with the nurse or doctor etc., thus spending more time in the ED,
- Time may be spent looking for a relative of the patient to give discharge instructions, especially if the relative is outside or in the cafeteria,
- As mentioned in an interview, a Nurse Practitioner (NP) feels that bedside registration will not really make things faster. It will all depend on the availability of beds or rooms in the ED to make the process faster. Till ED beds are available the patients will not be able to come in the back and no registration will be done,
- Sometimes, people walk into the ER and start peeping into the rooms looking for patients. They have to be directed by the nurses or other personnel to the nurses' station for enquiries,

- There is no cover for lunch and other breaks for the nurses and Physicians' Assistants (PA) in the MEC area. They have to cover for each other which gets difficult in busy times. Patients may have to wait for the PA to get back from lunch before they can be taken care of,
- It usually takes a long time to admit a patient and move them from the ED to another floor in the hospital, even after the decision for the admission has been made. So, the patient ends up spending substantial time in the ED even though they do not need to be there,
- Sometimes, patients have to wait for another physician to examine them which could take hours, before a decision on admission, transfer or surgery. The consultant might want to come to the ED only during lunch hour or after office hours,
- Some lab tests take longer and the patient has to wait till the results come in so that the PA can decide what course of management to follow.
- In the times the MEC is not open, brown charts are given to the patients admitted to the ED. There is an area on the charts in which a check mark is made to indicate if the patient is MEC or non-MEC. This will be confusing for the data recording observer till they look at the chart. If caught looking at the chart, it may indicate to the staff that this patient that is being observed. This may cause validity issues in case of the data collected by direct observation.
- If the patient is not fluent in English, it may take some time to get a translator for each interaction between the patient and the provider.

- While taking a patient for surgery, one of the beds was transferred to surgery with the patient and never returned. There was a time in the ED when there was a room without a bed thus causing shortage of beds in the ED and fewer number of patients could be serviced.

In spite of these limitations, it is still possible to use the techniques and tools to aim at improving the processes to serve patients better.

Through wise application of quantitative measurement skills and proven process improvement tools the healthcare industry can make great leaps towards world class quality levels. A faster and more efficient healthcare system is just a few Six Sigma steps away!

APPENDIX A

Observations of Best Practices

In preparation for the improvement phase of the Six Sigma project, several members of the team visited other hospitals' Emergency Departments in an effort to understand what the other hospitals had done to improve patient care. In November 2003, the team visited the ED at McKenna Hospital at New Braunfels, Texas and Brooks Army Medical Center at San Antonio, Texas. In September 2004, a few members of the team visited M. D. Anderson Cancer Center at Houston, Texas. At each facility, the team met with representatives from the hospital and were given an overview of the process improvements in the hospitals.

At McKenna Hospital in New Braunfels it was seen that the triage window was right in front of the entrance which made it natural for the patient to stop there rather than at any other station. The patients' minimum information is entered at Triage into the hospital computer. This is what was called the "mini-registration". Once the Triage is complete, the chart is placed in a rack in full view of the ED personnel and registration is done at bedside. The billing and payment is done after the care of the patient is complete. The goal at this ED is to get the patient in the back as soon as possible, the priority being to get them to the ED bed first. The patient chart uses check boxes to identify the patient's acuity level. The nurse station is in the center with the patient rooms all around it making it easy to monitor and access any room by the nurses. The ED personnel also use the clip and chart system where metal clips of different colors are attached to each chart to designate the current status of the patient and if the patient is waiting for any tests etc. Thus the clips provide visual control, which was also helped by the fact that the charts are placed in big open ended racks on the nurse station and are easily visible with their colored clips. There were separate racks for new charts, charts in the process of treatment and charts of discharged patients. Eventually, the hospital plans to replace the racks with white board in which the status of each patient would be easily available. In case of admissions, the staff calls the admissions unit early in the treatment process to make sure that the bed is available as soon as possible and the bed in the ED can be free to receive another patient. A lot of information systems including Pyxis drug dispensing system, PACS system etc. were conveniently placed close at hand in the nurses station. There is a process improvement team at work in the hospital which constantly looks to improve the process, decrease waiting times and hence increase revenue.

Future plans include addition of a second triage room which would segregate the high-acuity and low-acuity level patients and also separate the urgent and the non-urgent cases The ED has realized significant improvements in some areas. They were able to decrease the waiting times for the patients admitted to the hospital by 100 minutes from 257 minutes. In addition they were able to decrease the Length of Stay (LOS) for patients served by their "fast track" ED area to the current average of 113 minutes. Their goal is to reach an average of 90 minutes.

The waiting room of the Brooks Army Medical Center (BAMC) was quite large. There were plenty of seats and wheelchairs in the waiting area. Registration was handled at a central desk where the patients were classified as emergent or not. The emergency cases were immediately directed to the back. Two other acuity levels were used – urgent and non-urgent. Patients classified as urgent or non-urgent were processed through one of the four triage rooms located at one end of the waiting room. The Triage nurse could also place orders for radiology or laboratory tests from the Triage area. Non- urgent patients were routed through a fast track area located down the hallway adjacent to the registration desk.

The actual emergency room was a large spacious area with the nurses' station in the center and rooms all around it most of which were visible from the nurse station. Most of these tools to be used by the personnel were placed within easy reach in the central nurses' station and some equipment was arranged in the periphery of the ED. There was a rack which showed the process of the patient and the status. The radiology department was next to the ED and the labs were situated at the 5th floor. The specimens were sent up to the labs through a pneumatic chute and the lab results were made available to the doctors through the computer network. The ED also employs the PACS system to view the radiological images. BAMC is different from the other hospitals as it is a teaching hospital and any order given by the residents has to be signed off by the staff physician. Many different sub-processes in the ED are also employed. Another difference seen here was the presence of the Charge Nurse and the Bed Coordinator in order to facilitate a better flow for patients in and out of the ED.

Some of the projects in MD Anderson Cancer Center include ones in improving patient wait time for Subclavian insertion, main lab specimen processing, nurse response time, call center, new patient referral visit, ICU, medical pump errors, missed appointments, nurse scheduling, diagnostic imaging, GI Surgery, gynecology infection center, infection control, internal medicine inpatient consult process, rehabilitation thoracic surgery, improved drug reaction reporting, biomedical engineering, administration, brain and spine center, increasing user satisfaction with various machines, family care pharmacy, radiology etc. Continuous monitoring of the improvement with open discussion and suggestions by the staff, appreciation with balloons, meal vouchers, congratulatory, display and presentation of the results at a regular basis, encouraging the staff to attend educational meetings, suggestion boxes. Out of the more than 400 projects which are bring carried out at the Center, improving adverse drug reporting and identifying serious events more accurately was of major importance. They encouraged use of computers to fill in online forms for reporting incidents, and trained personnel to recognize the events as soon as possible. This project showed significant improvement over one year.

Improving nurse satisfaction with work schedule was another one of the projects where a self scheduling process along the set guidelines was started. Monitoring feedback and staying open to changes according to staff opinions was continued to make sure the improved nurse satisfaction scores do not fall back to the earlier levels.

The department of Biomedical Engineering had known for some time that the staff was not aware of the responsibilities of each position in the department and this was causing confusion in the daily work of the department. Awareness of the responsibilities and roles of the staff was encouraged by building a database with the information and encouraging the staff to familiarize themselves with the information in the database. The staff felt it would be beneficial for the working of the department and it could be monitored over time with surveys to see how it had helped.

Each patient in the hospital has a charge ticket which shows a record of the charges incurred in their care. Completion of the charge ticket for the patients was a problem because there were a lot of incomplete tickets which led to loss of revenue for the hospital due to their inability to get reimbursed for the care. A project was started which allowed complete billing and less loss of revenue for the hospital by using education, database of the bills and alarms for the patients whose bills were not complete. This led to a reduction in incomplete tickets from 10.74 % to 4.5%. Reports of missing charges weekly to monitor the incomplete bills were generated to monitor the process. As in all healthcare facilities, decreasing medical errors due to medication and mistaken identification, missed doses, delays and transcription was a big concern for the administration at the hospital. The project in this field used nurse education, proper labeling information, changing of labs to show a 90% improvement from March to July 2004. The staff is also constantly urged to monitor the changes in the process to make sure the rate does not fall back.

Reduction of verbal orders in the ICU and increase in written orders from 49 % to 80% by education of the new doctors, right of the nurses to refuse to write orders for the physicians, visual flyers etc. to enforce the policy, reduction in ineffective pages, minimizing response time for patients in respiratory therapy were some of the other areas in which the improvements were carried out. This project also emphasized that it would be safe for employees to express their opinions without the fear of retribution with idea boards. An increased responses rate from 21% to 47 % was seen in just one month.

APPENDIX B: Control Plan Summary

Process	Process Step	Input	Output	Target	Measurement Syst.	Who?	Current Control Method	Sample Size	Sample Frequency	Reaction Plan	Notes/Ideas
Chart	Triage to bed process	Sick Patient	Patient in Bed	15 minutes	Triage nurse assigns on patient's chart time that patient is triaged and time that patient is placed in a bed.	Triage Nurse	ER Clerk enters two times: Time patient signed in (from chart) and time patient in bed (from chart). Maintains control chart in Excel or Minitab.	1 Week of Patients	As needed.	If average cycle time goes outside of target, determine why? Personnel, volume, patient's acuity level?	What's the easiest method? Keep in a manual binder, then enter into the computer?
Chart	MEC In-bed to out-bed process	Patient in Bed	Patient Out/Admitted	60 minutes	X bar control chart maintained by the ER clerk.	ER Clerk	ER Clerk enters these two times into Minitab or Excel and determines the total number of minutes between these steps. ER Clerk maintains x bar control chart.	1 Week of Patients	Once per quarter	If control chart goes out of control, determine why this has happened (times not documented? Too many more emergent patients?)	Same as previous
Chart	Low acuity In-bed to out-bed process	Patient in Bed	Patient Out/Admitted	90 minutes	X bar control chart maintained by the ER clerk.	ER Clerk	ER Clerk enters these two times into Minitab or Excel and determines the total number of minutes between these steps. ER Clerk maintains x bar control chart.	1 Week of Patients	Once per quarter	If control chart goes out of control, determine why this has happened (times not documented? Too many more emergent patients?)	Same as previous
Personnel	Telephone Calls to ER	Call	Smothered ER Clerk	50% Reduction	Number of bogus calls coming into the ER (make list of bogus calls). Generate a "P" Chart.	ER Clerk	If ER Clerk is receiving too many unnecessary phone calls, reviews automated response system to determine if changes should be made.	Possibly randomize the time the number of calls collected. Eight total hours over randowmized time/day would be sufficient.	Randomize by day and by time block over a 24-hour period. Possibly study once per quarter.	Clerk reviews possible changes with ER Manager.	This has not yet been completed.
Personnel	Constant tracking down for questions/concerns.	Questions	Answers	50% Reduction		All ER Personnel	Look into pager and phone systems.				Look into phone systems for staff.
Equipment and Supplies	Equipment transportation to and from the ER.	Equipment Out	Equipment In	All Equipment returned to ER.	P chart on the pc. Of equipment that are lost vs. the total number of ED equipment assigned to dept.	ER Clerk	If not all pc. Of equipment returned, call floors for tagged equipment.	1 Month's worth of equipment counts.	Once per quarter.	If equipment is missing every week, employee training on returning equip.	Develop red tags and attach on all pc. Of equipment that is owned by the ER.
Equipment and Supplies	Medical Supply Shortages	Medical Supplies	Organized and accurate inventory.	Never a shortage of supplies.	X-bar chart on the number and types of supplies that the ER runs out of weekly.	ER Clerk	Check par level or normal usage of any supplies that run out.	Number of supplies that run out in 1 Month.	Once every six months.	Increase par level or add product to regular inventory list.	order items are written on white board on outside of
Process	**Process Step**	**Input**	**Output**	**Target**	**Measurement Syst.**	**Who?**	**Current Control Method**	**Sample Size**	**Sample Frequency**	**Reaction Plan**	**Notes/Ideas**
Lab	Turnaround Times	Order	Result	60 minutes or less.	P Chart on total number of labs per month that take over 60 minutes.	Lab Personnel	No Control	1 Month's worth of tracking.	As needed./Minimum quarterly.	Employee training on proper turnaround times.	
Lab	Unacceptable Specimens	Order	Result	No unacceptable specimens.	P chart on the number of specimens per month that are unacceptable.	Lab Personnel	Lab Personnel will call ER and have ER redraw the specimen./20 min. per failure	1 Month's worth of tracking.	As needed./Minimum quarterly.	Employee tracking, track the method used.	Have tubing system checked?
Lab	Technique of Blood Draw	Order	Result	5 minutes	P chart on number of specimens redrawn by lab personnel.	Lab Personnel	Lab personnel will redraw the specimens, however we just now started tracking the number of times that this is done.	1 Month's worth of tracking.	Once every quarter, then once every six months.	Training for ER personnel on techniques for drawing specimens, or have equipment tested.	
Process	**Process Step**	**Input**	**Output**	**Target**	**Measurement Syst.**	**Who?**	**Current Control Method**	**Sample Size**	**Sample Frequency**	**Reaction Plan**	**Notes/Ideas**
Personnel	Discharge Process	Doctor's Orders	Patient out the door.	15 minutes	Nurse captures time doctor's orders begin until time that patient is discharged from the ER.	ER Nurse	No Control.	1 Month's worth of tracking.	As needed.	If continues taking longer than 15 minutes, analyze reasons for lag.	
Personnel	Left without being seen.	Patient in ER bed.	Patient walking out before being seen.	15 or less/month.	ER Clerk captures the number of patients LWBS per month.	ER Clerk	No Control.	Quarterly tracking.	As needed.	Research reasons people are leaving if numbers go up.	

APPENDIX C

ED Service Level Calculation Sheet

Hospital:		Date:			
Service:		**Service:**			**CDM#**
Admission with or without orders	4	Pelvic Exam Assist	4	Circle one of the following CDM level codes	
Application of Ace wraps, Slings, C collar, taping and post-op shoe (do not use when reducing, splinting or dressing)	3	Personal Hygiene/ bathroom assist	2	ER level 1 Triage only	330-5315
Cardiac monitoring (order required)	4	Postpartum Care	8	ER level 1 follow up	330-5316
Decontamination, Simple	5	Restraint mgmt/combative pt	5	ER level 1 Basic (No points or procedures)	330-5226
Decontamination, Complex	8	Ring Cutter	2	ER level 2 procedure only (no points with procedure)	330-5309
DOA	5	Seizure observation/ care	4	ER level 2 (1-2 points)	330-5309
Drug Screen/Chain of Custody	2	Sexual Assault/rape kit	5	ER level 3 (3-6 points)	330-5261
Eye exam- tray set-up	2	Specimen collection-urine,stool,sputum etc (not including blood drawing)	2	ER level 4 (7-10 points)	330-5262
Emotional Care	4	Suctioning	2	ER level 5 (11+ points)	330-5263
Enema administration/ rectal Disimpaction	3	Surgery Consult	3	ER level 6 (Critical care)	330-5264
Fetal Heart Tones	2	Tracheal care	2		
Icepack	1	Transfer to another Acute, Rehab, Behavioral hospital	5	**Total Points**	
Isolation care/precautions	4	Transfer/ Return to Nursing Home or other	3		
IV preexisting	2	Transport to floor by ER w/ monitor	5		
IV insertion/ uncomplicated	3	Transport to floor by ER w/o monitor	3		
IV insertion/ complicated	4	US/CT/X-ray with nurse accompany	4		
Neuro checks(3 or more)	3	Visual Acuity testing	2		
Newborn care (cord care, warmer etc)	8	Vital Signs- Frequent (3 or more excluding orthostatic signs)	2		
Order entry (1) including Med orders	2	Vital Signs- Orthostatic	1		
Order entry (2) including Med orders	2	Wound dressing, cleaning and irrigation - simple (Not Repaired)	2		
Order entry (3) including Med Orders	3	Wound dressing, cleaning and irrigation - complex (Not Repaired)	3		
Order entry (4) including Med Orders	4				
Oxygen by cannula or mask	1				

This form is used to determine The "ED Service Level" of care provided to the patient

In addition to the ER Service Level visit charge, all procedures performed on/for the patient should be charged.

Only one ER Service level is to be charged for each episode of care

Level 1 patients are those that have no points and no procedure charges

Level 1 patients are those that either have no points but have a procedure billed on the ED charge sheet or that are assigned 1-2 points with or without a procedure

Level 6 (Critical Care) patients are not assigned any points

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