AN EXPLORATION OF QUALITY SYSTEMS IN HEALTHCARE FACILITIES

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Master of Science

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by

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Accepted by the faculty of the College of Science and Technology, Morehead State University, in partial fulfillment of the requirements for the Master of Science degree.

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Management philosophies and statistical process control methods as part of quality assurance in manufacturing received world-wide support throughout the past century. In contrast, the application of these philosophies within the healthcare industry is a recent evolution. Despite proven concepts and innovations, change has progressed slowly. Current managerial concepts and practices fail to recognize the value of customers from both an organizational and community perspective. As learned from its industrial counterpart, the concept of customer specifications or 'personalization' is a recent movement within healthcare facilities. Continuous Quality Improvement, Six Sigma, and Lean Six Sigma are the primary modes of quality improvement within healthcare. These organizational-wide philosophies provide comprehensive tools and problem solving techniques used to re-engineer, monitor, and maintain the numerous, critical processes found throughout hospital wards. An analysis utilizing statistical process

control tools for an acute care hospital will be utilized to emphasize how quality systems and their associated tools can provide support in defining, measuring, analyzing, improving, and controlling healthcare processes. This study will seek to define five key indicators as they relate to common hospital performance measures, measure and analyze continuous data for five key indicators utilizing control charts with Minitab statistical software, and improve and control key indicators with assignable causes and recommendations.

Accepted by: ______________________________, Chair
Dr. Ahmad Zargari

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Dr. Yuqui You

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Contents

Chapter 1: Introduction

1.1 History of Quality

Quality improvement orginally began with inventions such as the steam engine, printing press, and the clock. These inventions spured massive changes within industrial manufacturing. In the early strages of quality history, Walter A. Shewhart developed his methodologies for Statistical Process Control as a physicist at Bell Telephone Laboraties in the 1930s. Shewhart eventually developed the PDSA cycle as a problem solving method which is now associated with Lean Six Sigma. One of his students, Edwards W. Deming developed management concepts which can be found within his fourteen points. He believed that management was to retain responsibility for the overall quality of the business. Statistical Process Control and management principles grew within manufacturing during WWII in the 1940s. in 1946, The American Society for Quality Control was founded. By the 1970s, business were beginning to adopt quality assurance programs in efforts to utilized quality improvement as a prevention method. Philip Crosby, Joseph Juran and Armand Feigenbaum were the pioneers of the quality movement in the late 1970s which ultimately led to the creation of new quality standards. The need to establish standards in the 1980s resultred in the creation of Total Quality Management, ISO 9000 (later 9001), Six Sigma, and Lean Six Sigma.

1.2 Overview of Quality – a healthcare perspective

Many healthcare facilities receive demands from accreditation organizations, community-driven committees, and external customers in terms of what makes up quality healthcare. According to Sollecito et al. (2013), quality in healthcare began when Florence Nightingale's involvement as a nurse during the Crimean War utilizing descriptive statistics to discover a positive correlation between unsanitary conditions and patient death. Quality management in healthcare has evolved to organizational-wide involvement monitored by numerous accreditation agencies, laws, patient safety committees, and other quality control organizations. Several of these agencies include The Joint Commission, The Joint Commission International, Institute for Healthcare Improvement, CMS, Agency for Healthcare Research and Quality, and Network for Regional Healthcare Improvement.

The manufacturing industry has been improving and revitalizing quality standards since the 1920s. Even though quality in healthcare can be seen as far back as the 1850s, healthcare did not formally adopt quality management practices until recently, within the past twenty years. The slow adoption of quality into this industry is a much needed one. Fallon, Jr. et al (2013) explains the healthcare system has become a major part of the American economy since it generates 2.5 trillion dollars per year in spending and accounts for 17.6 percent of the gross domestic product.

According to Fallon, Jr. et al (2013), Continuous Quality Improvement was developed in the 1920s by Western Electric Company, a subsidiary of American Telephone and Telegraph Company. CQI was applied to manufacturing in its second wave in the 1940s by Motorola. This wave eventually died out until the concept of quality imrpovement was revived by Deming's management concepts and use of statistical process control tools. The movement gained further momentum in the 1970s through Juran's support of Deming's philsophies and tools. The quality movement in the healthcare industry received a final push from the Patient Protection and Affordable Care Act of 2010 at the local, state, and national level. It created organizations such as The Public Health Accreditation Board in 2011 and the Patient Centered Outcomes Research Institute. The purpose of the institute was to examine the effectiveness of various health treatments. Today, the Institute for Healthcare Improvement which was developed in 2010 is the leading organization in healthcare quality.

Total Quality Management, process re-design, and Six Sigma/Lean methdologies have taken on specific roles in healthcare management. Total Quality Management is typically utilized to repair a problem. Process re-design is necessary when a problem may be irreparable. Six Sigm/Lean methodologies are necessary when the problem is both strategic and irreparable. These methodologies are developed in heirarchal order depending on the severity of the problem.

Even though Six Sigma receives its origins from General Electric by Jack Welsh, this system not adopted by healthcare organizations until 2000s. Barrick (2009) describes the need for quality management as,“report cards for public knowledge, competitive advantage, accreditation requirements, customer satisfaction, and economic viability.”

1.3 Significance of Study

The application of quality management within the healthcare industry is both a broad topic and is considered a recent evolution within the last twenty years since the concept of quality improvement has been around since the 1920s. The industrial application of quality improvement was fully revived by Deming’s management principles and Joseph Juran in the 1970s which layed the foundation for application within the healthcare industry. There are numerous ideas, concepts, and formulas for success in the healthcare industry. Many of these concepts fail to recognize the value of customers from both an organizational and community perspective. While ‘personalization’ is becoming a movement within the American healthcare system, it is very recent and slow to become adopted. An organization can throw money at engineers to re-design a process, but if customer specifications are not amongst the top priority of items, then process improvement is a moot point. This is what healthcare has to learn from industrial manufacturing.

An approach of identifying specific quality systems that are applicable to the healthcare industry, providing examples of application, and an analysis of healthcare facility standards can provide a useful resource that is all encommpasing in terms of quality management. Each quality system has its own perspecitve of problem solving, and criteria that best meets the mission, set quality standards, and community needs of the organization. There is a considerable amount of nuances within the goals of each system, their differences, and how they allign with internal and external customer needs. The goal is not only to create a useful resource, but to perform an analysis of a hospital in terms of quality standards, performance, and customer expectations. The name of the facility in this research will be omitted since the appropriate permission was not granted for its publication.

1.4 Research Objectives

- Define five key indicators as they relate to common hospital performance measures.
- Measure and analyze continuous data for five key indicators utilizing control charts with Minitab statistical software.
- Improve and control key indicators with assignable causes and recommendations.

1.5 Assumptions and Limitations

Quality management has been a major proponent of industrial manufacturing for at least the past fifty years. Why has the healthcare industry become so slow in adopting quality management principles? Healthcare at the community, state, and national levels in all types of facilities is increasingly complex with direct impact on human life. Therefore, information and true statistical data is near-impossible to gather from a healthcare facility due to laws governing patient safety and the confidential nature of care delivery. For example, while a hospital pharmacy may be adopting quality management practices to lessen the number of medication errors occuring during the filling of orders, hospital management will not necessarily release that information openly to the public. This creates a lack of real data in the reasearch.

The lack of real data will be combated with the following reports:

- Annual Hospital Utilization and Services Report for years 1999- 2013.
- Annual Administrative Claims Data Report for years 2008- 2012 (Data Resource Gallery, 2014).

Another limitation to be considered is the fact the data is mined from published, government sources. This affects the internal validity of the study since the data cannot be accurately measured, only inferred. The data will be entirely based on publically available statistical reports, literature, and news articles. Due to the limitations, a definitive study and/or experiment cannot be performed. The scope of the data retrieved will be the most recent that is published through previously mentioned sources and will focus on the current state of quality improvement in healthcare application.

This research provides the assumption that the audience has a specific interest in quality management as it relates to the healthcare industry and holds rudimentary knowledge of quality improvement, statistics, and common problem solving tools.

1.6 Definition of terms

Quality Improvement is a formal approach to the analysis of performance and systematic efforts to improve it. There are numerous models used (What is Quality Improvement?, 2014).

Quality Management consists of activities and functions involved in determination of quality policy and its implementation through means such as quality planning and quality assurance (Quality Management, 2015).

Total Quality Management is an effort in which all members of an organization participate in improving processes, products, services, and the culture in which they work (Total Quality Management, 2015).

Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process – from manufacturing to transactional and from product to service (What is Six Sigma?, 2015).

Lean Six Sigma is a managerial approach that combines Six Sigma methods and tools and the lean manufacturing/lean enterprise philosophy, striving to eliminate waste of physical resources, time, effort and talent, while assuring quality in production and organizational processes (Lean Six Sigma Definition, 2014).

Continuous Quality Improvement is an approach to quality management that builds upon traditional quality assurance methods by emphasizing the organization and systems: it focuses on "process" rather than the individual; it recognizes both internal and external "customers"; it promotes the need for objective data to analyze and improve processes (CQI, 2015).

Cost of Poor Quality includes all the labor cost, rework cost, disposition costs, and material costs that have been added to the unit up to the point of rejection (Cost of Poor Quality – COPQ, 2015).

Attribute Charts plot characteristics for data in categories such as defective, non-defective, conforming, and nonconforming. These charts measure defects in counts, units, and proportions (What are Attributes Control Charts?, 2015).

Variable Charts are control charts that are used to evaluate variation in a process where the measurement is a variable--i.e. the variable can be measured on a continuous scale (e.g. height, weight, length, concentration) (Variables Charts, 2015).

Statistical Process Control is the use of valid analytical statistical methods to identify the existence of special causes of variation in a process (Quality American, Inc., 2013).

Chapter 2: Literature Review

2.1 Healthcare Facility Processes

Healthcare processes are usually cross-functional and multifaceted. Specific problems that occur within a process includes disconnect in which there is poor information transfer between points, bottleneck where volumne overwhelms capacity, redundancy, and rework. Each of these problems are preventable through balancing of the organizational structure, education, problem solving tools, and monitoring of quality improvements.

The core processes make up clinical care services in which sample sizes are used to address quality issues on an individual level. Public Health Departments often use population sizes in quality measurements since its focus is on the community as a whole rather than individual patients. Support processes make up another function of healthcare facilities. These processes are typically services that enable core proccessess to function such as the finance department or human resources.

2.2 Identifying the Customer

Healthcare facilities are complex by nature and serve many purposes. It is assumed that the only customer is the patient. However, customer relationships within healthcare vary as well. There are two types of customers, internal and external. It is important for departments and employees to identify their customers in order to successfully measure and monitor processes. To identify a customer, Sollecito et al. (2013) offers the following definition, “the receiver of a provided service and/or product.” There must be a direct exchange of goods and/or services to develop a customer-supplier relationship.

Therefore, there are two types of customers known as internal and external. Sollecito et al. (2013) identifies internal customers as providers, suppliers, facility (service lines), and billing.

Healthcare providers are often customers of ancillary services such as radiology in order to aid in the diagnosis of their patients. The facility can become a customer through its inter-departmental relationships. An example of this is the Quality Management department providing process re-engineering services for a service line. Anotther facility customer would be its stakeholders since they have direct influence on the operations of the facility. The billing or finance department often becomes a customer since the majority use third party agencies due to the volume of requests that occur each day.

Sollecito et al. (2013) identifies external customers as patients, families of patients, surrounding community, government agencies, managed care agencies, and insurance companies. Government agencies typically include accreditation organizations, medicare, and medicaid. Managed care facilities such as nursing homes often outsource their patients to primary care physicians and hospitals in cases of emergencies. Lastly, insurance companies receive billing quieres from healthcare institutions for processing in exchange for the provision of patient services.

2.3 Patient Involvement

Since the services offered by healthcare facilities often directly affects human life, external customers such as patients like to be involved within their own healthcare via direct or indirect means. Customers can be involved on the micro, meso, and macro levels. Within the micro level, the patient is directly involved within the decision-making process of his/her treatment plans. A 'personalized' treatment plan is most effective for management of chronic illnesses since the treatments are highly involved. Patients are educated about their treatment and provide the healthcare provider with permission to move forward.

The second and third levels of involvement are indirect. The meso level allows the community to become involved through workshops, conferences, committees, groups, patient satisfaction surveys, exit interviews, questionnaires, patient advocacy, and focus groups. It is common for a community to utilize a patient saftey or patient advocacy group in order to monitor the quality of healthcare services from the outside while offering patients a voice. T

Macro involvement concerns patient safety activities at the national and international levels. This largely involves the public reporting of providers for patients to make informed decisions. The goal of macro involvement is to engage healthcare systems to initiate reporting processes, ensure data is reliable, create accessible information, and provide healthcare providers with performance evaluations. An example of a patient safety organization is the World Health Organization's Patients for Patient Safety.

2.4 Organizational Structure

The organizational structure has a major impact on the quality of services provided as well as how quality improvement is implemented. Common aspects found in organizational culture within the healthcare industry consist of differentiation and integration. These concepts explain how employees are organizaed.

Differentiation occurs when workers are separated into different subunites through specialization in one task or activity. This is used to add quality and value to goods and services. This is often found by creating positions in which employees are specialists in their fields. Integration is also another important factor in the work place. This is the degree to which activities or tasks are coordinated among subunits of a system. This is common in healthcare since workers come together to produce a product or service. An example of this is a service line, in which different departmetns are centered around producing the same services to the customer.

Organizational structures represent six key elements as stated by Fallon, Jr. et al (2013), strategy, environment, life cyucle, size, technology, and culture. A quality system must regard these concepts and how they might impact the functionality. An example of an organizational structure for a quality system is featured below in Figure 1: Lean six sigma organization structure.

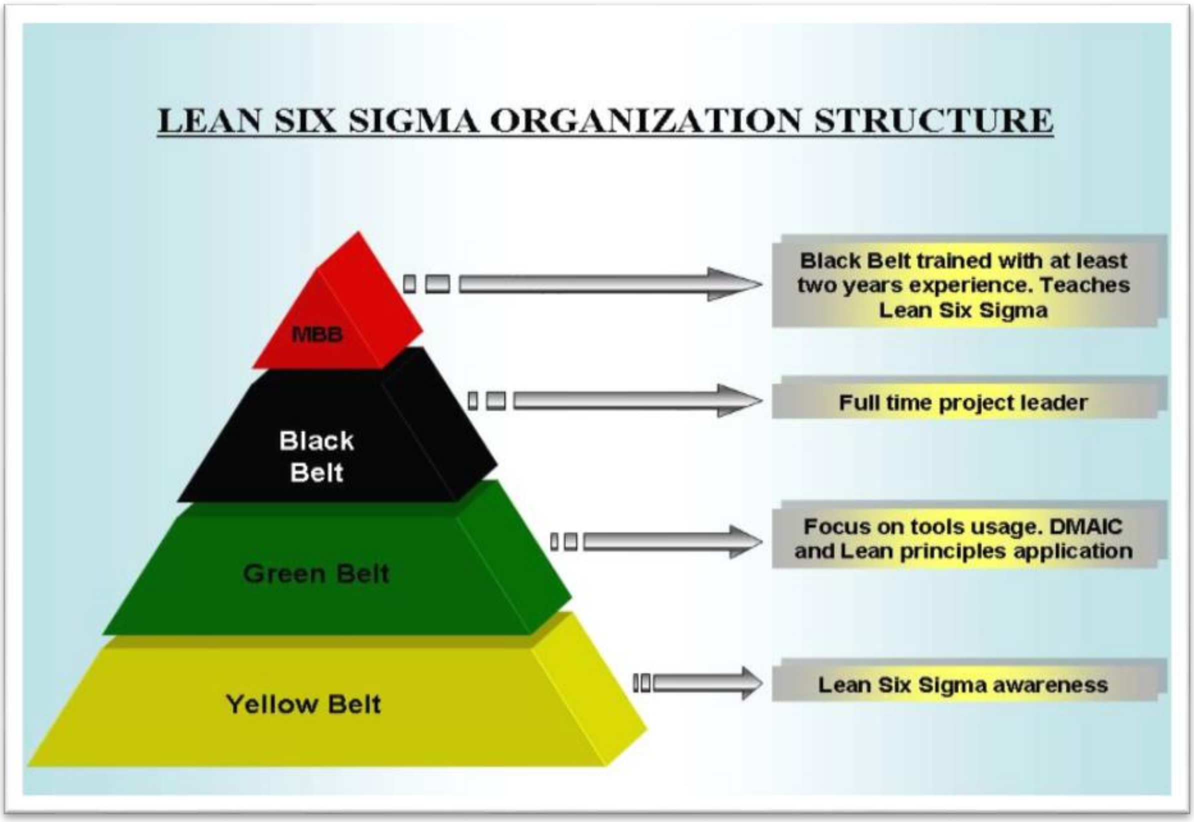

Figure 1: Lean six sigma organizational structure. Retrieved from: LEAN SIX SIGMA: LEAN SIX SIGMA ORGANIZATION STRUCTURE. (n.d.). Retrieved February 13, 2015, from http://consulenza-iso9001-eng.blogspot.com/2012/01/lean-six-sigma-organization-structure.html.

2.5 Continuous Quality Improvement

In addition to the quality systems of Six Sigma, Lean Six Sigma, and Total Quality Management, another quality system developed in the 1940s by a phone company receives its revival within the healthcare industry. Continuous Quality Improvement is a broad perspective on quality management that applies specific Six Sigma, and Lean Six Sigma methodologies. CQI recognizes the need for the involvement of management, the importance of customer specifications, and the need to reduce wastes within processes. This broad perspective emphasizes simplicity and community involvement to spur the innovation of quality control beyond that of its industrial counterparts.

2.5.1 Philosophy

A quality system requires change throughout the entirety of the organization in order for its installation to become a success. This concept stretches back through history to Deming who believed management should be the first to undergo a transformation. CQI strongly emphasizes the future rather than the 'here and now.' This model strives to remain simplistic by making small changes, then rapidly expanding the scope. In order to best utilize problem solving tools and management techniques, the organization will need to define its needs and applicable problem solving methods.

Continuous Quality Improvement requires key features such as an organizational strategic plan, committee for quality control, personnel training programs, tools for selecting improvement opportunities, process improvement teams, process analysis and redesign which are optimized for accreditation requirements, cost control, competition for customers, organizational and community needs. Fallon, Jr. et al (2013) states CQI should, "create programs that deliver to the needs of the community in both preventative and ongoing care, activities should enhance community health, measures are data-driven and outcomes are measurable." The overall goal of CQI is to remain simple and objective in quality improvement opportunities. The majority of healthcare facilities such as a hospital or a private doctor's office will usually have these requirements in place. CQI seeks to organize these key features into a simple and comprehensible system for improvement that meets the performance measures as identified by accreditation organizations.

Continuous Quality Improvement has several performance characteristics as listed by Sollecito et al. (2013), "Localized improvement efforts, organizational learning, process re-engineering, and evidence based medicine management." The CQI philosophy is broken down into six main categories listed below,

- Strategic focus.
- Consumer focus.
- Systems view.
- Data driven analysis.
- Solutions.
- Organizational learning (Sollecito et al, 2013).

This philosophy primarily emphasizes the need for a mission statement, consumer satisfaction, and empirical research. Its structure resides within its applications through project teams, problem solving tools, statistical analysis, customer specifications, and benchmarking. Each of these aspects allow CQI to facilitate critical thinking in a project-based environment for the re-design of healthcare systems and/or programs. This philosophy is further emphasized through several initiatives for the purpose of defining continuous improvement within a healthcare setting.

2.5.2 Healthcare Quality Initiatives

Quality systems were originally conceived to optimize the factory floor and involve management within the improvement process. While healthcare facilities are by nature, more complex than a factory floor, this industry can learn much from the original model. The industrial model emphasizes greater attention to customer specifications, greater attention to the design of processes and systems, gives employees the opportunities to be self-monitoring, need for management support, statistical process control methods, and education for employees in quality monitoring. Due to changes in healthcare applications, customer specifications are now becoming more and more emphasized through greater personalization of treatment plans and utilization of electronic records. In addition, healthcare facilities typically utilize organizational-wide involvement with quality such as the patient, doctors, nurses, engineers, and housekeeping staff.

According to Sollecito et al (2013), the improvement initiatives for CQI include Localized improvement efforts, organizational learning, process re-engineering, and evidence-based medicine management. The initiatives seek to provide employee training at all levels about quality improvement and utilize empirical research as the foundation for all decisions regarding process re-engineering or improvement opportunities. This is achieved through the following:

- Organizational strategic plan.
- Quality committee consisting of top management.
- Personnel training programs.
- Tools for selecting improvement opportunities.
- Process improvement teams.
- Process analysis and redesign (Sollecito et al, 2013).

These initiatives are optimized for process improvement, competitive advantage, and conformance requirements set by customers.

2.5.3 Quality Structure

These initiatives are addressed by the structure for CQI which is as follows: project teams, problem solving tools, quality engineers, customer satisfaction, benchmarking, and specifications. An integral part of CQI's structure is its use of the FOCUS-PDSA cycle.

- **F**ind a process to improve.
- **O**rganize team that knows the process.
- **C**larify current knowledge of the process.
- **U**nderstand causes of process variation.
- **S**elect the process improvement (Sollecito et al, 2013).

This is used in conjunction with Plan, Do, Study, Act which is also known as Plan, Do, Check, Act, and the Shewhart cycle. FOCUS is a mnemonic used to organize the project team and gain a systematic understanding of the process to be improved before the planning phase of the PDSA cycle can begin.

The problem solving tools typically utilized include: brainstorming, flowcharts, force field analysis, Ishikawa-fishbone diagram, nominal group technique, contingency diagramming, Pareto chart, run chart, control charts, and ANOVA. The run chart, control charts and ANOVA are also recognized as Statistical Process Control methods. SPC methods are an integral part to any quality system and in which processes are controlled and monitored for stability.

These tools also allow the organization to assess the competition which is known as benchmarking. This is also a common tool used throughout the quality systems due to its numerous benefits. Assessing the competition allows a facility to learn new concepts that are successful within other organizations. The concept of continuous improvement does not only cover products and services, it also covers the individuals within the organization. The organization can only master success if its employees are willing to learn from successful models. In addition, benchmarking allows a facility to increase both their customer and economic growth. Fallon, Jr. et al (2013) mentions the Institute of Medicine and its six aims for improvement, "safe, timely, effective, efficient, patient-centered, equitable." These aims emphasize that healthcare delivery facilities should avoid injuries, reduce harmful delays, provide services only to those who benefit, avoid waste, personalize treatment, and zero tolerance in variance of quality. Emphasis is placed on systems thinking rather than individual providers.

2.6 Systems Thinking

An individual who comes to the realization that decisions have implications for the organization as well as consumers, and stakeholders has engaged in systems thinking. This mode of thought allows individuals such as managers to consider relationships and long term effects in decision-making. Fallon, Jr. et al (2013) further reiterate systems thinking as, "interrelationships between parts as they relate to the functioning whole (pg. 5)." Systems thinking gains its importance from the fact that the many interrelationships found within a healthcare facility such as a hopistal can directly affect human life. Fortunately, there are tools to encourage systems thinking within the workplace.

The most commonly used tool is a casual loop diagram. The diagram displays a reinforcing loop in which change leads to more change throughout the organization. A balancing loop occurs when change in one direction leads to resistance in the opposite direction. An example of balancing loop is a budget analysis. The change creates resistance due to relization of cost limitations. Change that is undesirable such as organizational downsizing is known as a negative reinforcing loop. Other terms used in conjunction with this diagram include fixes that fail and drifting goals. Fallon, Jr. et al (2013) refer to fixes that fail as immediate solutions with adverse long-term consequence. Drifting goods are referred to as performance that is allowed to negatively impact the workplace by Fallon, Jr. et al (2013).

2.7 Problem Solving Tools

All of the quality systems have produced a set of problem solving tools and group discussion techniques to facilitate their respective cycles such as the DMAIC and PDSA.
The tools that will be discussed in further detail include brainstorming, flowcharts, force field analysis, Ishikawa-fishbone diagram, nominal group technique, contingency diagramming, Pareto chart, run chart, and control charts. This is a list of common and effective tools and group techniques to be used in quality management.

2.7.1 Pareto Chart

Pareto charts are very common and useful in that they identify problems, classify collected data by categories and type, arranging data by cumulative percentage, and draws a cumulative pareto curve which displays the problems that account for eighty percent of the whole. The concept being the Pareto chart is to focus on eight percent of the total defects to maximize time and money. Pareto charts can be used for a broad spectrum of defects to address issues associated with electronic documents, record keeping, medication errors, etc. A situation in which defects can be characterized and counted can be mapped via a pareto chart. Pareto charts are typically associated within the “plan” stage of PDSA or the “define” stage within the DMAIC cycles. This tool can also be used to check for control within the “act” or “control” stages of their respective cyles. An example of a pareto chart modeling medication errors can be referenced in appendix C. These errors are generalized, and fabricated using the Minitab 17 software program in order to create a sample chart.

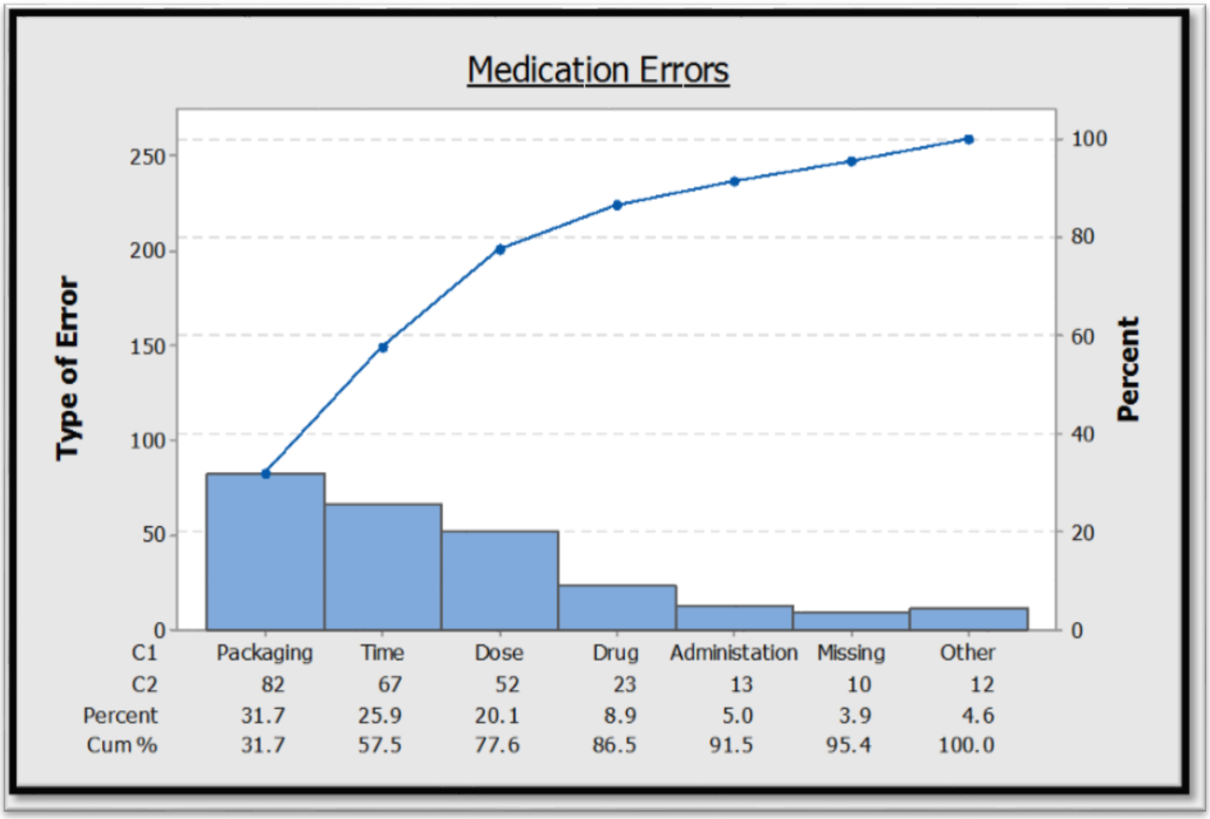

Figure 2: Pareto chart example of medication errors. Retrieved through personal use of Minitab 17 software program. The data chosen was fabricated by the author to simulate an example related to healthcare.

2.7.2 Flowchart

Flowcharts are simplistic in design, but have many capabilities within process improvement. Their purpose is to facilitate a collaborative understanding of a process and visualize the relationships found among process components. Especially in Lean Six Sigma methodologies, it is important to map the process both before and after improvement. In order to develop an effective flowchart, a quality manager should follow these steps:

- Define the start, end, key workflow components, and decision points.
- Document each step, then review with the team.
- Define assumptions to avoid confusion.
- Sequence each event.
- Assign the symbols for flow (arrow), diamond (decision), oval (start/finish), and rectangle (key operations).
- Validate with the appropriate personnel.
- Identify and correct any gaps (Barrick, 2009).

An example of a flow chart is shown below in Figure 2: Sample high-level flowchart for ischemic heart disease patient flow. A subsequent list of shapes and descriptions can also be referenced in appendix A: Flow chart shapes and definitions.

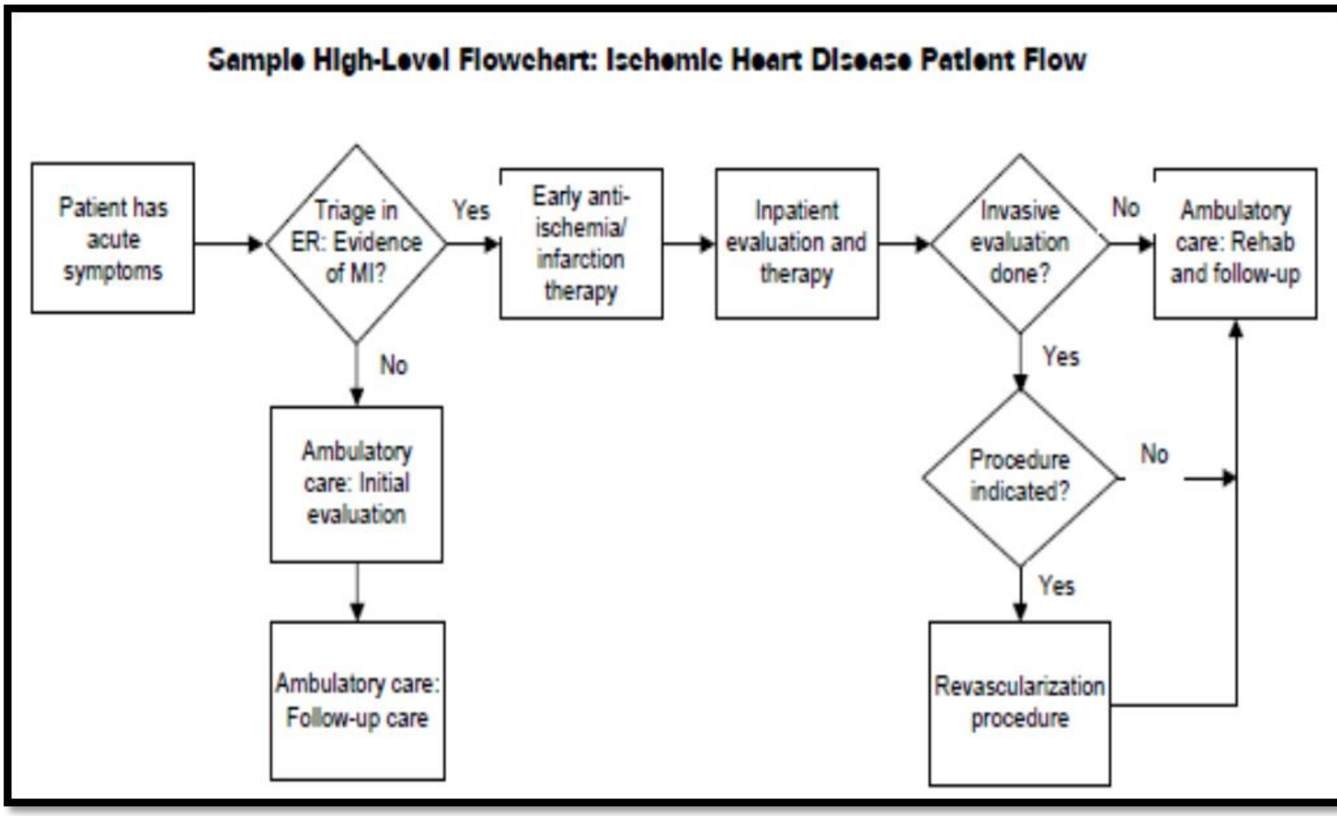

Figure 3: Sample high-level flowchart for ischemic heart disease patient flow. Retrieved from: Process Analysis Tools. (2004, January 1). Retrieved April 4, 2015, from http://nnphi.org/CMSuploads/Flowcharts Guide.pdf.

2.7.3 Value Stream Map

Internal processes in healthcare can range from file organization to a thirty-step bed rotation that can account for two hours of time. There are several levels of mapping a process which serve different purposes. Flow mapping is a basic way of visualizing a process in which each step is identified from the beginning to the end.

A more detailed and high-level of process mapping consists of a value-stream analysis IN which a map outlines all aspects of a process relative to the value of the service received by the customer. This is a Lean Six Sigma problem solving tool since the map's primary purpose is to increase value to the customer by identifying and removing wastes inherent within the process. Therefore, it is important to identify what value is. Value is what the customer is willing to pay for in order to receive a product or service.

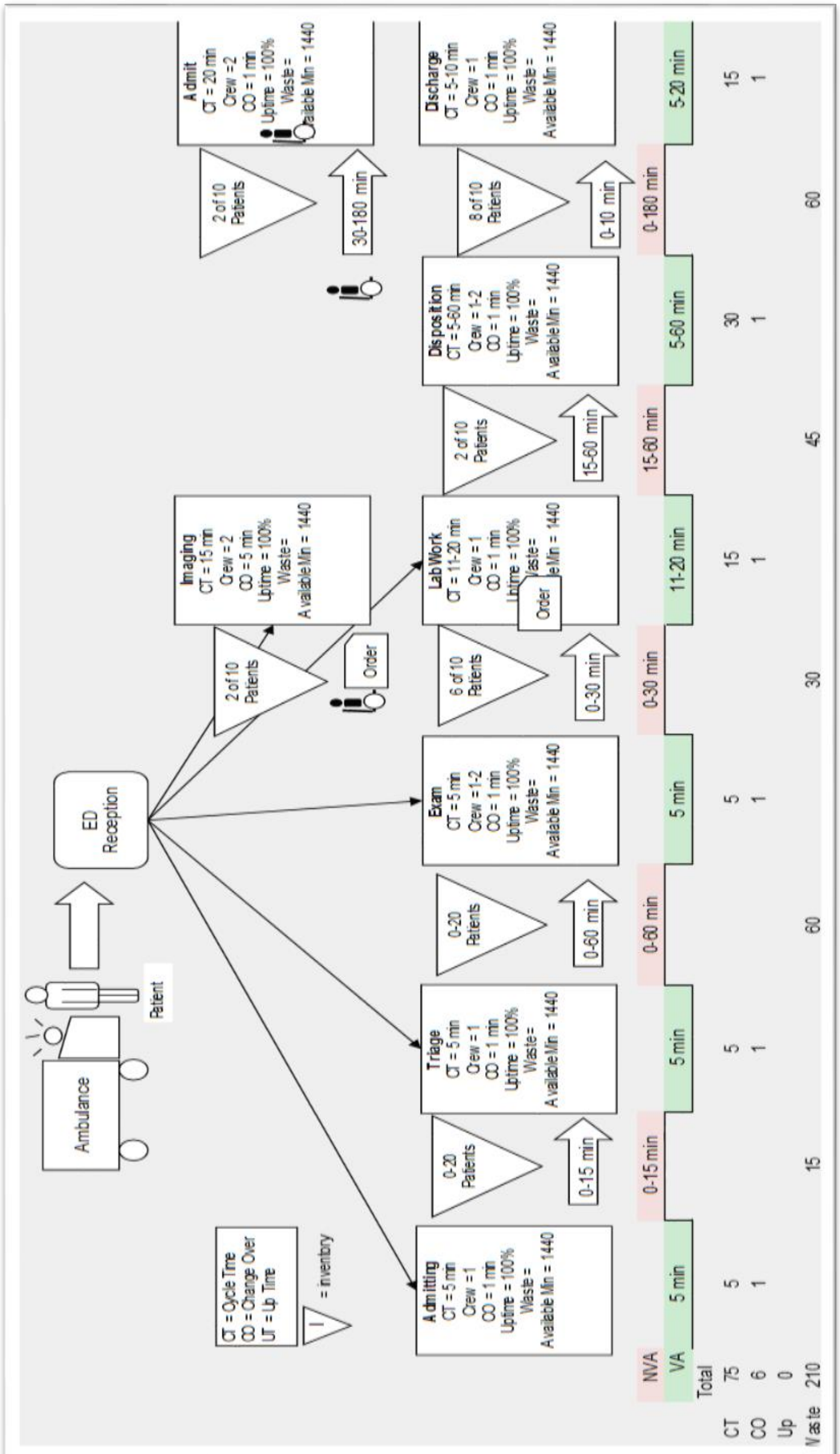

Figure 4: Value stream map example for emergency department. Retrieved from: John D. Dingell VA Medical Center, Detroit, Michigan. (n.d.). Retrieved April 10, 2015, from http://www.detroit.va.gov.

As seen in Figure 3: Value stream map example for emergency department, the value stream clearly outlines the information and material flows in addition to value-added and non-value added times within the lead time ladder at the bottom. Barry (2013) outlines the importance of VSM within healthcare, “By identifying all of the steps, you can start to map the whole process out, moving from left to right. . . an ideal future state map can be created. . . These can identify areas for improvement, and once implemented, they can become the “new” current state map as part of an iterative quality improvement process.” An in-depth explanation of the shapes and their definitions can be found in Appendix G: Value stream shapes and definitions.

2.7.4 Fishbone Diagram

Ishikawa was the creator of this problem solving tool. The purpose of a fishbone diagram is to conduct a brainstorming session with team members in order to identfy root causes of a problem(s). The chart is constructed by drawing the spine, add the main causes along the spine, then add specific causes along each main causes. This tool forces team members to look at the root problems, not the symptoms using the ‘5 whys’ method. The team will gain a collective knowledge about a problem through asking questions about why each problem occurs.

This process will repeat itself until the team has come to a consensus on the root cause of a problem. This is largely a brainstorming method in which all ideas are valid and considered. The categories present within the Ishikawa diagram in a healthcare sense includes personnel, policy, process, and procedure. This analyzes the core policies, personnel linked to the process, methods, materials, and equipment. This dispersion analysis categorizes causes utilizing the 5 whys, and creates a before and after picture of problem resulotion. This is also known as mapping the current and future states of process/problem. An example of a fishbone diagram is shown below in Figure 4: Fishbone diagram example for waiting time. Other names include: Ishikawa diagram (names after its creator), and a Cause and Effect diagram. This chart is primarily referred to as a Fishbone diagram since its image imbodies that of a fish skeleton.

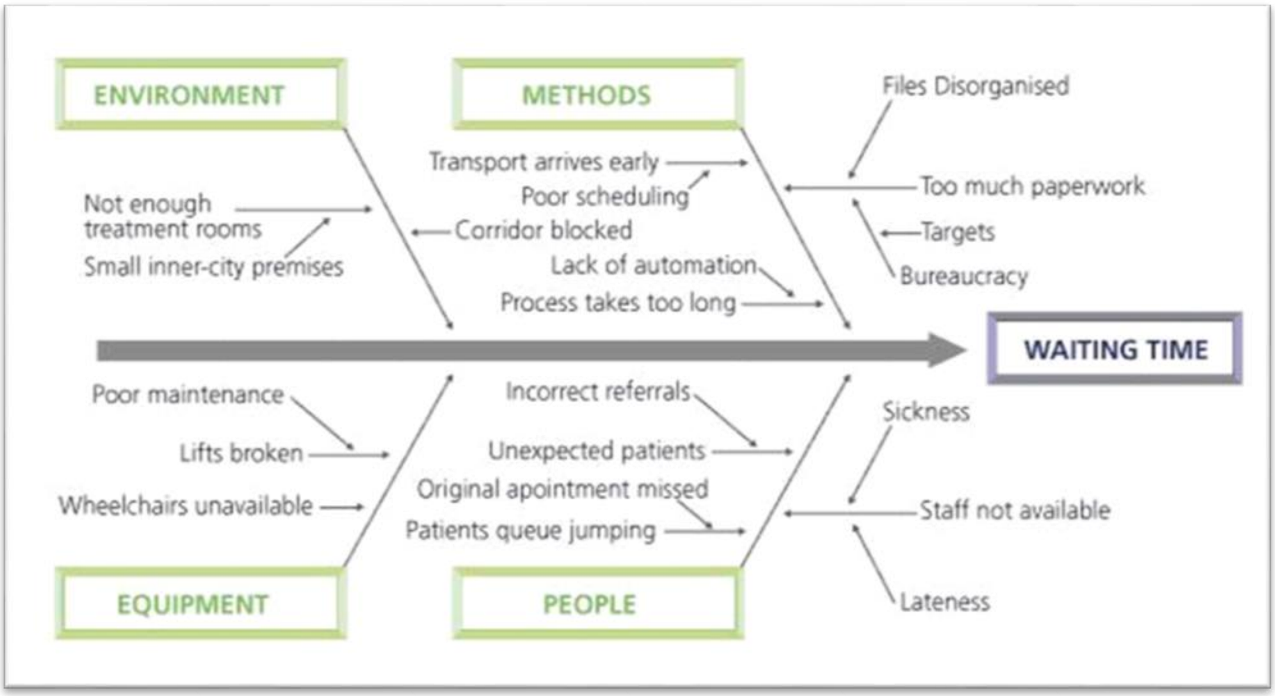

Figure 5: Fishbone diagram example for waiting time. Retrieved from:
John D. Dingell VA Medical Center, Detroit, Michigan. (n.d.). Retrieved April 10, 2015, from http://www.detroit.va.gov.

2.7.5 Statistical Process Control Tools

Statistical process control tools such as run charts and control charts test process variation and capability depending on variables, type of data, and samples vs. population. The run chart is the simplest of these tools that measures continuous data over the mean of the sample or population being measured. A run chart can be referenced in appendix D. This run chart features fabricated data utilizing the Minitab 17 software program. This tool highlights process change and variation while studying observations. The focus should only be on significant changes, in which the quality manager will isolate and develop further investigation into the causes behind the variation.

Deming developed principles to understand to control and manager process variation (Barrick 2009). There are two types of variations that can be found in control charts such as common cause and special cause variations. Common cause variations are inherent within a process and to be expected. Special cause variations and not inherent, but can be controllable by a quality manager. All variations fall within these two categories. However, Deming also believed that management should take greater responsibility for these variations. Therefore, managers are responsible for common cause variation since special cause variation is out of his/her control. It is also the role of management to define what is inherent within and process and what is not. Guiding questions used within a brainstorming session can define the common cause variations. The statistical process control tools analyze process capability which drives and sustains quality improvements. There are control charts to measure different types of data, variation, and subgroup sizes. These charts fall into the categories of attribute and variable which each service a specific purpose. Examples of attribute and variable charts can be referenced later in the study in which variable charts and additional problem solving tools will be used to analyze several data sets.

Another form of statistical process control is a regression analysis or ANOVA. The purpose of this is for hypothesis testing regarding strength of associations as a forcasting model. This forcasting model is complex and the data required depends on the type of ANOVA being used. This is often used in conjunction with a scatterplot diagram for its use in identifying relationships between plots of data.

2.7.6 Project Facilitation Techniques

Since critical care processes and the majority of support processes have a direct effect on human life within the healthcare industry, there are specific problems or controversial topics that may cause team members to become hostile. Leading a project team in itself requires a skilled leader. However, there are discussion tools such as contingency diagramming and the nominal group technique. Contingency diagramming uses reverse psychology and forces team members to view negative aspects of a process from a different perspective. Instead of only concerning themselves with their relative complaints, team members are asked to list every way in which the process can become worse. After the team comes to a consesus on a list, an action plan is built off of those issues. The key steps of this technique are outlined by Barrick (2009) and include: ask for ideas, document actions, do not tolerate criticism, continue until ideas are exhausted, clarify ideas with disucession, identify actions, and develop an action plan to document correction actions.

The nomincal group technique is not necessarily used exclusively for hostile team discussions, but can be of help when the team cannot come to a consensus on a decision. Instead of brainstorming, the team comes to a consensus after deining a sequence of actions in rank order. A list of topics or decisions is listed on a flip-chart. The team then clarifies meanings of each decision. A final list is made using letters in which team members are asked to write three letters on a piece of paper in rank order using numbers. Should a team member feel storngly about a subject, they can cast their votes for one item or choose how to distribute their votes. However, they should only have one vote per item listed. This process determines the overall ranking of the decisions listed. This is a somewhat lengthy process that will most likely take several cycles to complete a final list the team can agree upon.

Another important problem solving tool is a force field analysis. This tool is less common than a pareto or control chart, but has significant value within a project team. The purpose of this analysis is to identfy barriers to process improvement recommendations.

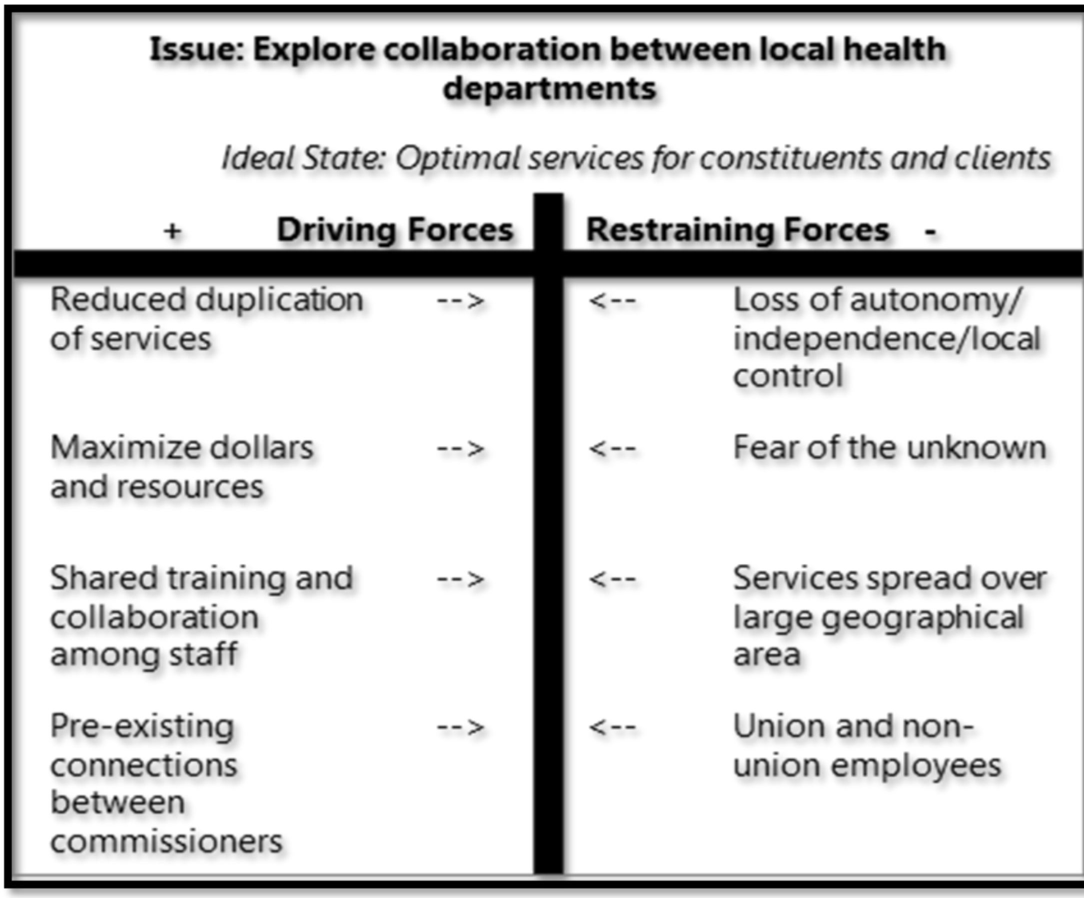

Figure 6: Force field analysis between local health departments. Department of Health. (n.d.). Retrieved April 4, 2015, from http://www.health.state.mn.us/divs/opi/qi/toolbox/forcefield.html.

An example of this tool is shown above in Figure 5: Force field analysis between local health departments. This will develop an understanding of the existing organizational culture and policies. A force field analysis identifies driving and restraining forces. Driving forces are likely to support a situation requiring change. Restraining forces and likely to impede a desired change. An example of a force field analysis can be referenced in appendix G. Barrick (2009) explains change only occurs when the drive force is greater than the restraining force. Idenfying these forces can encourage the team, stimulate creative thinking, expedite consensus building, and provide a starting point for action (Barrick 2009).

2.8 Six Sigma

Like all quality systems, Six Sigma has its roots in manufacturing. Six Sigma is not just a list of problem solving tools, it is a methodology that becomes intertwined within the fabric of the organizational culture. Due to this characteristic, this quality system takes time and an organiztaional wide committement for success. Change management also becomes an importance aspect due to organizational involvement. Barrick (2009) explains this as Six Sigma thinking in which employees utilize technical and analytical capabilities, project management experience, and team facilitation to achieve goals.

Table 1: Sigma level identification. Retrived from: Barrick, I. (2009). Transforming health care management: Integrating technology strategies. Sudbury, Mass.: Jones and Bartlett.

Sigma Level	Quality Yield	Cost of Poor Quality
2	69.0%	Uncompetitive
3	93.3%	25-40%
4	99.4%	15-25%
5	99.8%	5-15%
6	99.97%	< 1%

The basis of Six Sigma is in its measure of defects per one million parts in order to recover costs of poor quality. Table 1: Sigma level identificaiton displays overall quality of products and/or services produced at each sigma level. The cost of poor quality is the amount of money the company or organization spends on corrective actions due to defects. The higher the sigma level, the greater the economic viability of the organization. According to Barrick (2009), the majority of healthcare facilities operate at two or three sigma.

The Six Sigma organizational model has four levels within a hirarchy consisting of operations, processes, business, and leaders at the top. Changes made at the operations level are overseen by senior management and team leaders. Changes made at the process level are overseen by department directors. Lastly, changes made at the business level are overseen by organization leaders. Higher level problems are often a result of organizational dysfunction. Barrick (2009) describes Six Sigma thinking as organizational realignment, infrastructure development, system mapping, key driver determination, and results tracking. These qualities remove the 'project by project' mindset and encourage employees to become multitaskers.

Each quality system has its own problem solving process and Six Sigma is no exception. This system utilizes the DMAIC cycle.

- Define: plan for sustainable improvement.
- Measure: know what to measure and how to measure process performance gaps.
- Analyze: process performance gaps against benchmarcks, uncover solutions used by more successful organizations.
- Improve: system, application, and process elements to achieve performance goals, define and use metrics to analyze data, prioritize remedial actions.
- Control: monitor changes made to process (Barrick 2009).

Figure 7: DMAIC cycle for six sigma. Retrieved from:Graves, A. (2012, December 7). What is DMAIC? Retrieved April 10, 2015, from http://www.sixsigmadaily.com/what-is-dmaic.

In the define stage, it is important to identify the process owner, the customers, and stakeholders when developing a plan.

Six Sigma thinking emphasizes mistakes as learning experiences and encourages realistic goal setting, and standardize systems to specifications. This mode of thinking strives to answer the question, What causes operational dysfunction?

- Ineffectively linked systems (Barrick 2009).
- Variation in the use of services.
- Underuse and overuse of services.
- Misuse of services resulting in errors (Aikens, 2011).

2.9 Lean Six Sigma

This quality system also become embedded within the organizational culture. Lean manufacturing was developed by the Toyota Motor Company using the ‘just-in-time’ philosohpy. The main goal of Lean manufacturing is to eliminate waste found in processes. This identifies value-added and non-value added time and cuts down work that does not add value. In removing non-value added time, the work flow becomes smoother and more efficient. Common errors found within the healthcare industry include duplication of patient information and delays in services. This system follows the PDCA/PDSA cycle, otherwise known as Plan, Do, Check, Act or Plan, Do, Study, Act.

The key concepts of Lean manufacturing include:

- Lean enterprise metrics.
- Strategies, tools, and principoles that increase efficiency, decrease waste, and improve quality.
- Value stream mapping.
- Error proofing and standardizing operations.
- Push vs. pull systems and takt time (Barrick 2009).

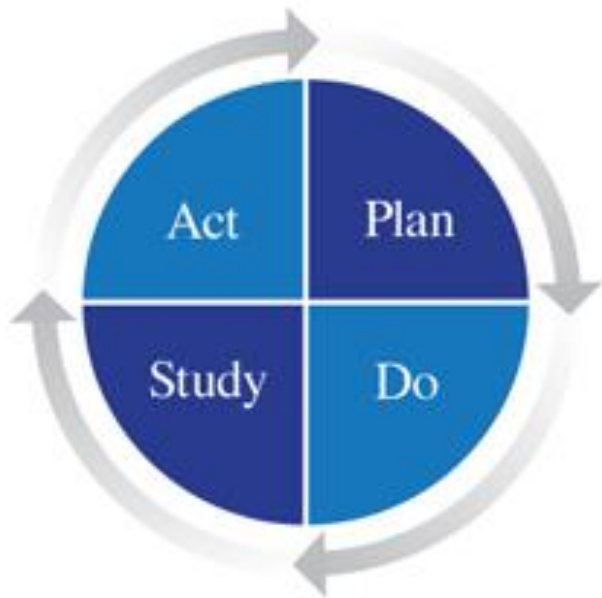

Figure 8: PDSA cycle for lean six sigma. Retrieved from: THE PLAN, DO, STUDY, ACT (PDSA) CYCLE | The Deming Institute. (2015). Retrieved April 10, 2015, from https://www.deming.org/theman/theories/pdsacycle.

A major proponent of Lean is its visual management capabilities. Barrick (2009) states, “Visual management highlights and focuses relevant resources on opportunities by visualizeing process elements from input to output through key aspects of value transformation.” This describes the use of Value Stream Mapping which is often utilized to improve work flow, display personnel, material, and information flow, and distinquish between value-added and non-value-added time. This is also a method used to optimize takt time and meet patient demand requirements or specifications within a process.

The value stream works as a push system which is ideal in Lean methodology. A pull system strives to remove non-value added steps within a process. Example of non-value added time is system downtime, unnecessary movement, and unnecessary rework. The main proponent of a pull system is it only delivers services as requested by other services downstream. This maximizes efficiency and removes any redundancies or unessescary flow from a process.

A push system is not ideal in lean methodology since builds up waste within a process. This system adds hand-off activities to downstream processes. The problem with excessive hand-offs is they have the high probability of delay since there is greater and mostly unecessary workload involved within the process.

Another form of visual management is 5S Organization which is defined by Barrick (2009) as, “Sorting, shining, setting in order, standardizing, and sustaining.” This creates effective tast execution, exposes and removes errors, and applies relevant counter-measures to prevent reoccurances. A more general description would be the 5S system is simply a method to clean and organize the workplace so employees can work more efficiently. Lean manufacturing operates on consistent, deliberate, and visual leadership. This system also promotes a zero tolerance policy of errors, defects, and/or waste.

Chapter 3: Methodology

3. 1 Research Design

The primary goal of this research is to create an all-encompassing resource identifying specific quality systems that are applicable to the healthcare industry, providing examples of application, and provide a time study of major processes that enable a hospital to function. The research objectives are as follows:

- Define five key indicators as they relate to common hospital performance measures.
- Measure and analyze continuous data for five key indicators utilizing control charts with Minitab statistical software.
- Improve and control key indicators with assignable causes and recommendations.

The data includes information for a short-term, acute care hospital. Appropriate permission was not granted for use of any identifiable factors for the facility studied within this research. Therefore, both the name of the state and the facility will be omitted. The five key indicators in which data will be provided include: admissions, inpatient days, average length of stay, outpatient visits, and inpatient surgeries.

The nature of the data will be continuous since key measures will be studied over a period of thirteen-fourteen years. Continuous data will be organized using Microsoft Excel in order to further measure and analyze the data utilizing the Minitab 17 software program. The data is analyzed utilizing run charts, and I-MR charts. The purpose of a run chart is to illustrate the trend of the data points. There will be one data point for each year, for a total of fourteen data points.

If applicable, the distribution of the data will be analyzed utilizing histograms with a fit line, organized with a pie chart, and/or organized with a pareto chart. As explained previously in

Chapter 2, pareto charts are primarily used as defect identifying and tracking tools. The purpose of the pareto chart as a data analysis tool will change in order to organized the data by percentage, rather than identify it's defects.

3.2 Data Collection Methods

The first objective involves the identification and collection of data retrieved from the following reports:

- Annual Hospital Utilization and Services Report for years 1999- 2013.
- Annual Administrative Claims Data Report for years 2008- 2012 (Data Resource Gallery, 2014).

The Annual Hospital Utilization and Services Report is published by the corresponding state government. The earliest published report begins in the year of 1999 and ends in the year of 2013. These reports feature extensive, and all-inclusive data for the major patient care services in a hospital. Each report averages one-hundred and fifty pages each covers the following:

- Hospital Utilization and Services Decade Review.
- Hospital Utilization Data by Licensed Bed Type.
- Acute Bed Utilization.
- Service Utilization (Data Resource Gallery, 2014).

The hospital utilization data featured in this report includes: licensed acute beds, licensed psych beds, total licensed beds, beds in operation, admissions, inpatient days, discharges, discharge days, ADC, average length of stay, and occupancy percentage. These categories are applied to the following sections:

- Acute and psychiatric care utilization.
- Critical access hospital utilization.
- Long term acute hospital care beds.
- Acute and psychiatric care and critical access utilization.
- Acute non-psychiatric inpatient utilization.
- Psychiatric inpatient.
- Childern and adolescents 0-17 years of age – psychiatric inpatient utilization.
- Adolescents 13-17 years of age – psychiatric inpatient utilization.
- Adult 18 years of age and over – psychiatric inpatient utilization.
- Adult 18-64 years of age – psychiatric inpatient utilization.
- Adult 65 years of age and older – psychiatric utilization.
- Swing bed inpatient utilization.
- Chemical dependency inpatient utilization.
- Physical rehabilitation inpatient utilization (Data Resource Gallery, 2014).

Further data for acute bed utilization is provided for every hospital facility in that state under the following sections: inpatient utilization of acute care beds in operation; inpatient utilization of intensive care beds; newborn nursery and neonatal care. The service utilization section of this report includes operating rooms and cystoscopy rooms, and inpatient surgical operations.

One of the primary sections of this report utilized for data analysis within this study is outpatient utilization by facility and region. Data is featured in the following categories: ER outpatient visits, other outpatient, and total outpatient. The remainder of the document includes data for CT scans by facility and region, adult transplants, pediatric transplants, and lithotripter procedures by facility and region.

The majority of the data was gathered via the hospital utilization reports. However, inpatient data for Medicare and Medicaid services were moved into the Annual Administrative Claims Data Report for Inpatient Hospitalizations from the years 2010-2012. This is why the inpatient Medicare and Medcaid data spans from 1999-2012, while the other data sets range from 1999-2013. These documents are considerably smaller and utilized as a combined report, rather than a comprehensive report of all hospital services. These reports were also published by the state and contain an average of fifty-five pages. The report contains the following categories:

- Maps of the locations of hospitals in the state.
- Trending charts.
- Inpatient hospitalization days by facility and payor.
- Inpatient hospitalizations – leading twenty-five MS-DRGs.
- Inpatient hospitalizations – summary of categories by quarter and hospital ADD.

The inpatient data utlized within these reports is found in the beginning of the document under Inpatient Hospitalization Days by Facility and Payor. The categories featured are: medicaid inpatient days, medicaid percent of total, medicare inpatient days, medicare percent of total, commercial inpatient days, commercial percent of total, other inpatient days, other percent of total, and total inpatient days. This data is included for a total of fifteen regions which include all hospitals in the state.

The data from the previously mentioned documents were organized within an Microsoft Excel document in which five key indicators were chosen for further measurement and analysis.

3.2.1 Key Indicators

As per the first, second, and third objectives, the collected data features key indicators which include a combination of processes and measures for a small, acute care hospital. The five key indicators include:

1. Admissions.
2. Inpatient Days.
3. Average Length of Stay.
4. Outpatient Visits.
5. Inpatient Surgeries.

The data for all key indicators will be housed within two Microsoft Excel spreadsheets. The first spreadsheet will include inpatient utlization data while the second spreadsheet will include outpatient utilziation data. The first key indicator, admissions was gathered from the Annual Hospital Utilization and Services Report for years 1999- 2013. The admissions include patients in acute and psychiatric care utilziation. Since the reports have a fourteen year range, the organization of the reports changed over time as well.

The section, acute and psychiatric care utilization remained constant throughout the reports and included the most inclusive data for the hospital. In addition, short-term acute care is the primary function of this hospital. The majority of hospital utilization encompasses acute care since these services provide short-term treatment for a severe injury, illness, medical condition, or recovery from a surgical procedure. This is why the admissions indicator covers multiple processes since patients can be admitted into wards that specialize in a multitude of treatments. In addition, a combination of acute, critical, and long-term care services was not provided within these reports. Admissions will be measured with a histogram, run chart, and an I-MR chart.

The second key indicator data was collected from the Annual Hospital Utilization and Services Report for years 1999- 2013, and the Annual Administrative Claims Data Report for Inpatient Hospitalizations from the years 2010-2012. Inpatient days include data by number of days spent by patients within the hospital. Inpatient days reflect the patients in acute care and psychiatric services.

The inpatient days was organized by Medicare, Medicaid, total, and all other consumers. Each section of data includes numbers in the thousands. The categories for inpatient days was further organized by year from 1999-2012 due to missing 2013 data for Medicare and Medicaid patients. This key indicator is measured with a pie chart, Pareto chart, histogram, run chart, and an I-MR chart. Another widespread quality measure hospitals use is average length of stay.

Average length of stay simply measures how many days patients spent in the hospital on average. This measures the efficiency of care delivery within a hospital. However, average length of stay can be influenced by multiple factors. The most notable factor being certain illnesses or operations require additional time to recover. However, this performance measure will only include data for acute and psychiatric care within the Annual Hospital Utilization and Services Report for years 1999- 2013. Long-term care and critical care will not be assessed in this study. This key indicator will be measured with a histogram, run chart, and I-MR chart. While three key indicators measure inpatient utilization, outpatient data also includes significant information as to how the hospital's internal processes are functioning.

Outpatient visits is the fourth key indicator to be measured and analyzed. However, there are multiple types of outpatient visits, therefore this indicator will be organized into emergency room visits and non-critical visits found within the Annual Hospital Utilization and Services Report for years 1999- 2013. Non-critical visits simply accounts for outpatient procedures that are not life-threatening. Since the facility is a short-term acute care facility, the majority of outpatient visits make up doctor's appointments, and/or non-invasive surgical procedures. This data also reflects that of acute and psychiatric care only. Outpatient visits will be measured with histograms, run charts, and I-MR charts. This hospital also provides services used for inpatients and outpatients.

The final key indicator, inpatient/outpatient surgeries will be generalized into ambulatory surgeries and inpatient surgeries. This data was pulled from the Annual Hospital Utilization and Services Report for years 1999- 2013. Ambulatory surgeries are known as same-day surgeries for outpatients. These are non-invasive procedures that do not require an over-night hospital stay. Inpatient surgeries reflect more invasive procedures that require an over-night stay throughout the hospital. The utilization reports generalize the data to include acute, psychiatric, long-term, and critical care sections of the hospital. Inpatient/outpatient surgeries will be measured and analyzed with pie charts, histograms, run charts, and I-MR charts.

Chapter 4: Findings

4.1 Data organization

All data is found within the Annual Hospital Utilization and Services Report for years 1999- 2013 and the Annual Administrative Claims Data Report for years 2008- 2012 (Data Resource Gallery, 2014). The Annual Hospital Utilization and Services Report is published by the state. Appropriate permission was not granted for use of any identifiable factors for the facility studied within this research. Therefore, both the name of the state and the facility will be omitted. Data for the five key indicators of admissions, inpatient days, average length of stay, outpatient visits, and inpatient/outpatient surgeries is organized into two Microsoft Excel spreadsheets that can be referenced in appendix B: data organization for inpatient utilization, and appendix C: data organization for outpatient utilization.

The inpatient utilization data for the hospital is organized into the following categories: beds in operation, admissions, discharges, inpatient days, and average length of stay. Beds in operation was organized into acute, psychiatric, and total beds. This information was used to determine if hospitals beds could be used as a key indicator for this study. However, the only analysis that can be gleamed from this data is the hospital has retained the same number of beds in operation for the past fourteen years. Even-though this data was not measured, it does provide an analysis that the hospital has not grown in size in terms of bed count for acute and psychiatric care.

Admissions and discharges reflect the total numbers for acute and psychiatric care patients. When measured utilizing run charts, the discharge data was near-identical to that of the discharge data. While there are small differences, no real significant information can be inferred from measuring both admissions and discharges. In addition, inpatient days was organized into

Medicare, Medicaid, total, and other. The chart that can be referenced in appendix C: data organization for inpatient utilization indicates the missing data for the year 2013 for Medicare and Medicaid patients. The final category for this spreadsheet is the average length of stay which is measured by number of days. The other key indicators feature outpatient utilization data.

The second spreadsheet of data can be referenced in appendix D: data organization for outpatient utilization. This table is organized by year into the following categories: emergency room visits, other visits, total visits, inpatient surgeries, ambulatory surgeries, and total inpatient/outpatient surgeries. All data is measured by number of patients for all aspects of the hospital.

4.2 Key indicator for admissions

The first step in measuring the hospital's admissions for acute and psychiatric care services was to ascertain the distribution of the data along with the descriptive statistics. The following chats are constructed using the Minitab 17 software program. The first chart to be used was a histogram with a fit line as seen below in Figure 8: histogram of admissions.

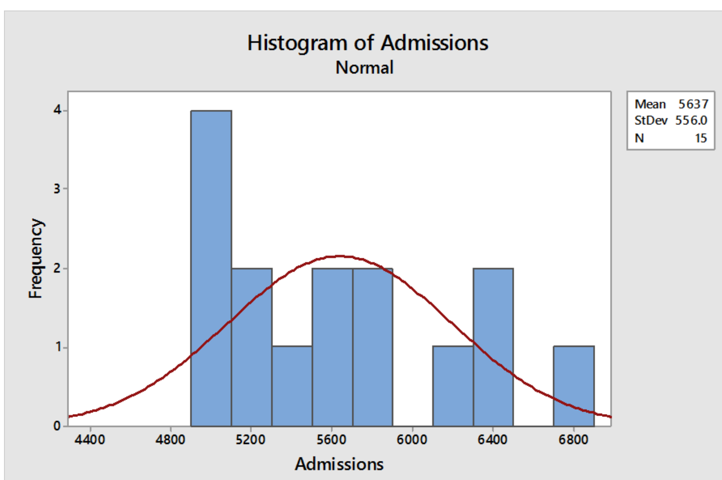

Figure 9: Histogram of admissions. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

The histogram is another useful tool that can be utilized in CQI, Six Sigma, and Lean Six Sigma methodologies. The purpose of this tool is to provide the descriptive statistics for mean and standard deviation in addition to the frequency and distribution of the data. The y-axis portrays the spread of data. The x-axis portrays the frequencies of data. Each data point is grouped together by frequency within a specified range. This histogram illustrates the data is primarily grouped between 4,800 and 6,000 admissions with a mean of 5,637. An outlier of 6,800 has influenced the mean to be on the high side since the majority of the frequencies lie within the range of 4,800 to 5,200. The difference between the highest and lowest numbers on the y-axis equals to that of 2,400. This indicates the data has a larger spread than expected since the number of patient beds referenced previously do not show any growth or decline in hospital activity. In addition, other findings show the data is skewed to the left which indicates that it is a non-normal distribution. Finally, the data does not fit the distribution well as the bars do not closely follow the fit-line. In order to investigate these findings further, a run chart featured below in Figure 10: Run chart of admissions has been constructed using the same data points.

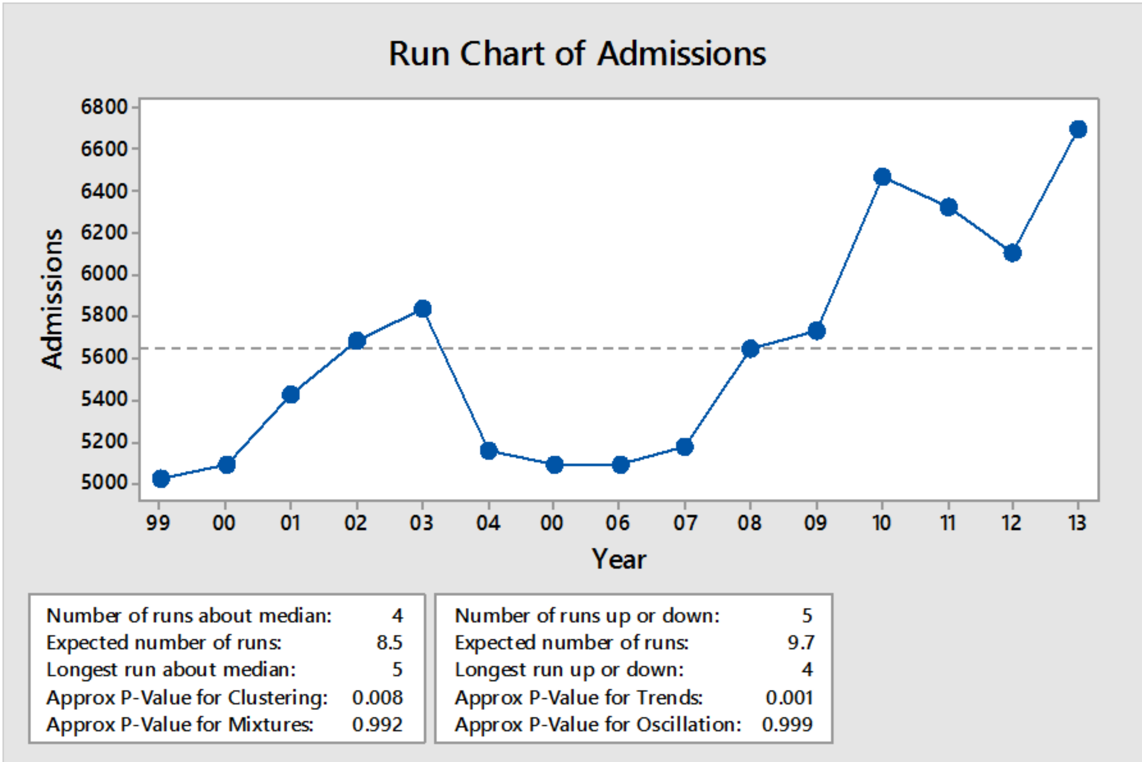

Figure 10: Run chart of admissions. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

While admissions have grown considerably by 1,681 admissions from the years 1999 to 2013, the data in between shows a significant drop in admissions after the year 2003. Admissions do not begin to grow again until the year 2007 in which there is a sharp increase. If a process is in control, the nature of the data will most likely be consistent. There may be some variation in which there are no extremes. However, this chart displays significant variation in the data. In order to acquire more accurate results, this data is analyzed via an I-MR chart. This chart is much like that of an X bar-R chart. Both charts test for control using variable data. However, X bar-R charts use subgroup sizes greater than one, while I-MR charts do not. Since each data point represents one year, my subgroup size was one. In addition, the data points follow a specific order.

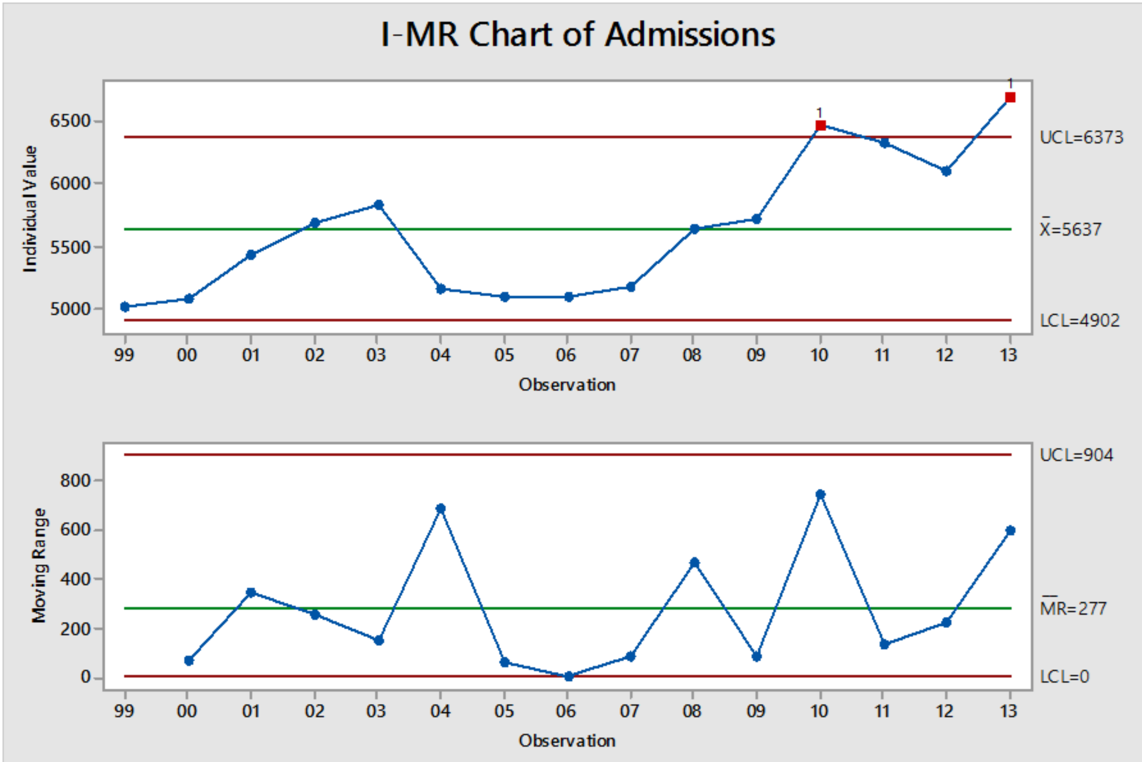

Figure 11: I-MR chart of admissions. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

The variable chart shown above in Figure 11: I-MR chart of admissions displays the upper and lower control limits on top in addition to the moving range on bottom. The moving range is a result of an automatic subgroup size of two in which the difference between two data points is calculated, then averaged to provide the moving range. The years 2010 and 2013 are the data points that are out of control, therefore the admission process for acute and psychiatric care is out of limit. In addition, the data for individuals and moving range is not consistently spread along the center line. A process within limits equals to stability, which ensures the process in question is providing a service of high quality. The points that are out of limit in this chart are the same years in which there was significant growth as defined by the run chart in Figure 10: Run chart of admissions. Two possible assignable causes that are strictly based on the data collected include: the hospital is too small for a large number of admissions and needs to outsource patients to other hospitals, or the hospital needs to increase the number of beds in operation to account for higher population density.

4.3 Key indicator for inpatient days

Inpatient days is part of the inpatient utilization data and is organized into three categories, Medicare, Medicaid, and other. The other category simply refers to all other patients outside of the two previous categories that received either acute or psychiatric care. The three categories, totals, and percentages of total inpatient days can be seen below in Figure 12: Pie chart of inpatient days. The primary finding of this pie chart is Medicare patients account for 50.3 percent or half of the population.

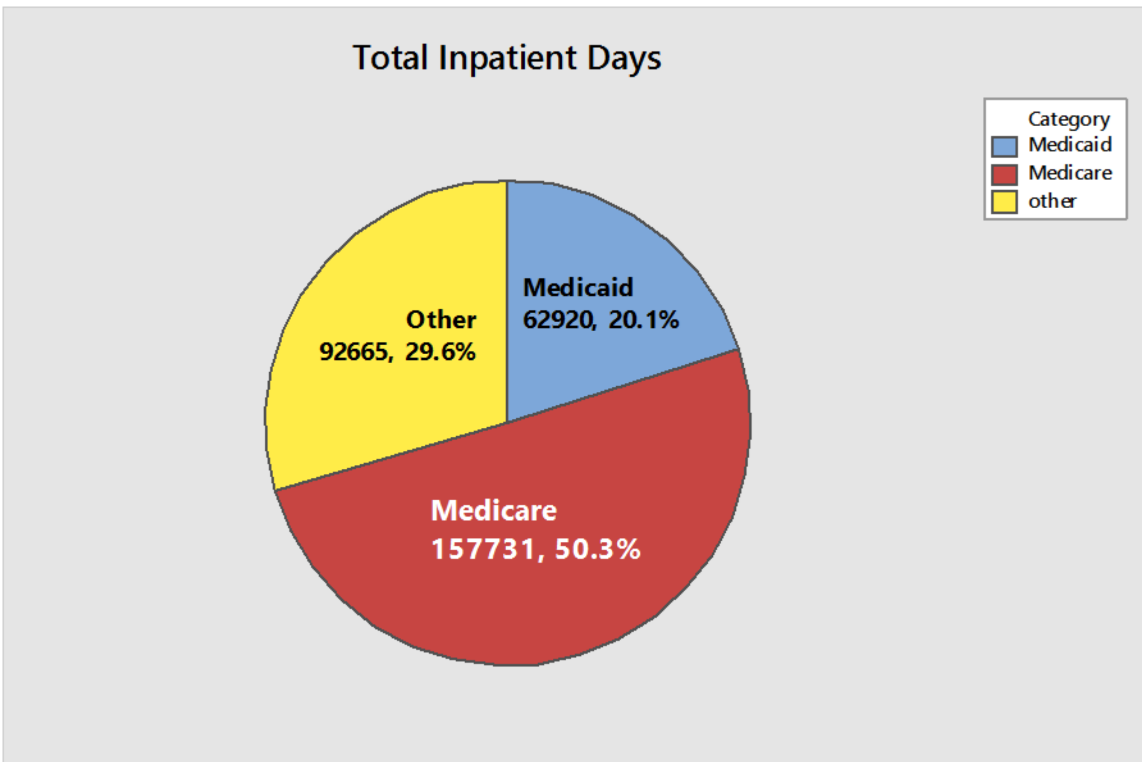

Figure 12: Pie chart of inpatient days. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

This same finding can also been seen below in Figure 13: Pareto chart of inpatient days. This chart organizes the data by cumulative percentages. Medicare and other inpatient days account for eighty percent of the population. However, since Medicare inpatient days is a more definitive process and accounts for half of the population, this category is investigated further.

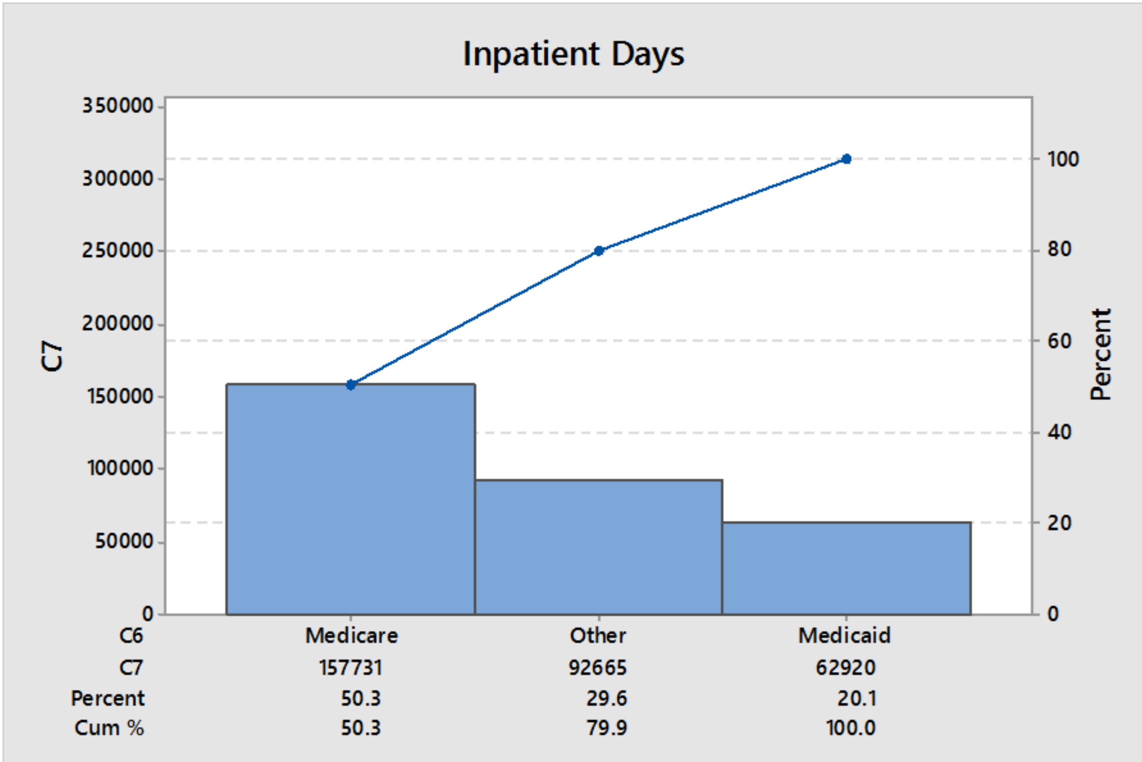

Figure 13: Pareto chart of inpatient days. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

The analysis of Medicare inpatient days follows the same pattern as admissions. The first step was to input the data into a histogram to not only view the descriptive statistics, but illustrate the distribution of the data as well. As shown below, Figure 14: Histogram of Medicare inpatient days shows the data is primarily distributed between 9,600 and 12,000. This is in-line with a mean of 11,267. There are two outliers on each end, however the outliers are small and have little influence on the mean. Another finding is the data bars are a poor fit for the distribution. This means the distribution is non-normal, however additional data could improve the accuracy which may provide a normal distribution.

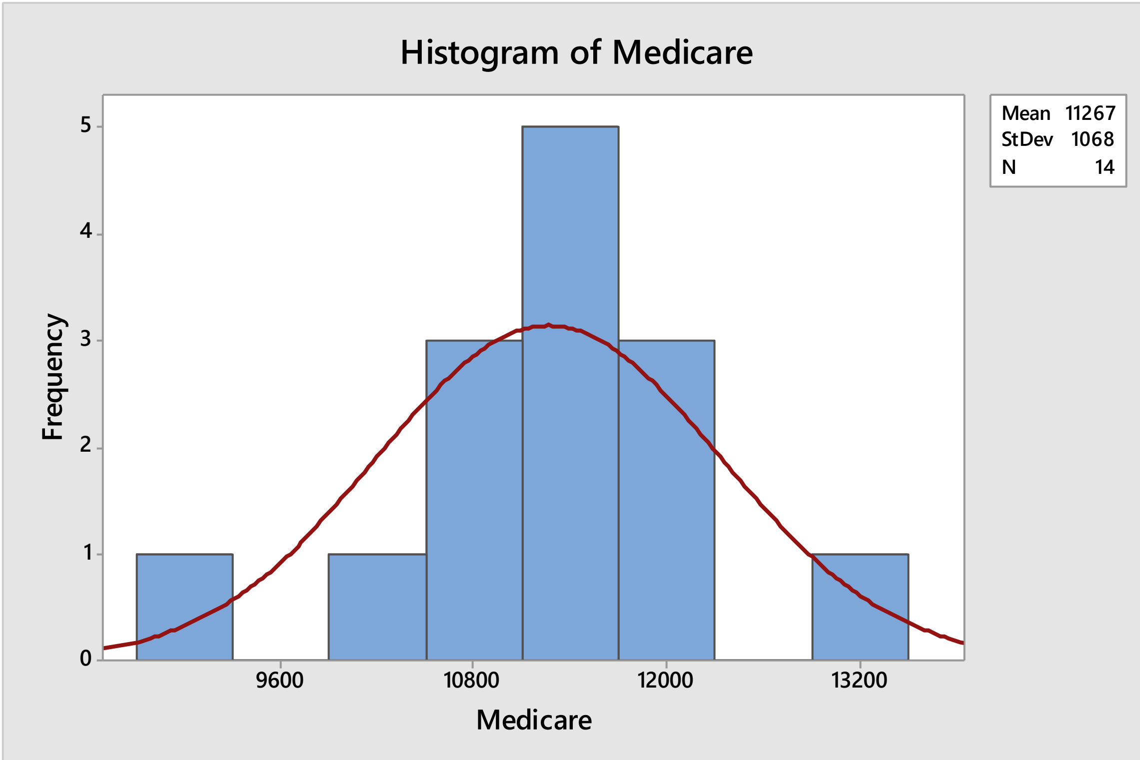

Figure 14: Histogram of Medicare inpatient days. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

After analyzing the distribution or spread of the data, a run chart is utilized for further analysis. The run chart shown below in Figure 15: Run chart of Medicare inpatient days features fourteen years-worth of data. From the years 1999 to 2003, the data is fairly consistent around the mean. However, there is a sharp decrease in Medicare patients after 2005, but a sharp increase after 2007. Due to the high variability around these data points, further investigation has indicated a significance with the year 2007.

The variable chart also shown below in Figure 16: MI-R chart of Medicare inpatient days illustrates the problem with the year 2007. In addition to the individuals chart, the moving range chart also features three points for 2000, 2002, and 2009 that are teetering on the edges of the control limits. Even though 2007 is the only point that is out of control, the process for Medicare inpatient days is still deemed as out-of-control. Further investigation into Medicare patients for the year 2007 will be needed to conclude the cause for the significant variation.

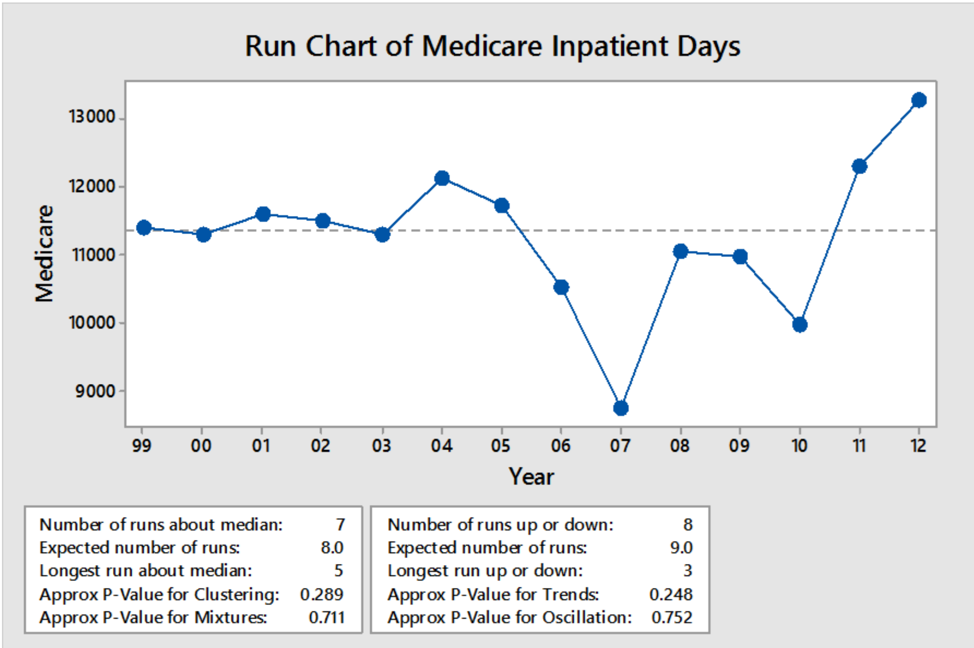

Figure 15: Run chart of Medicare inpatient days. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

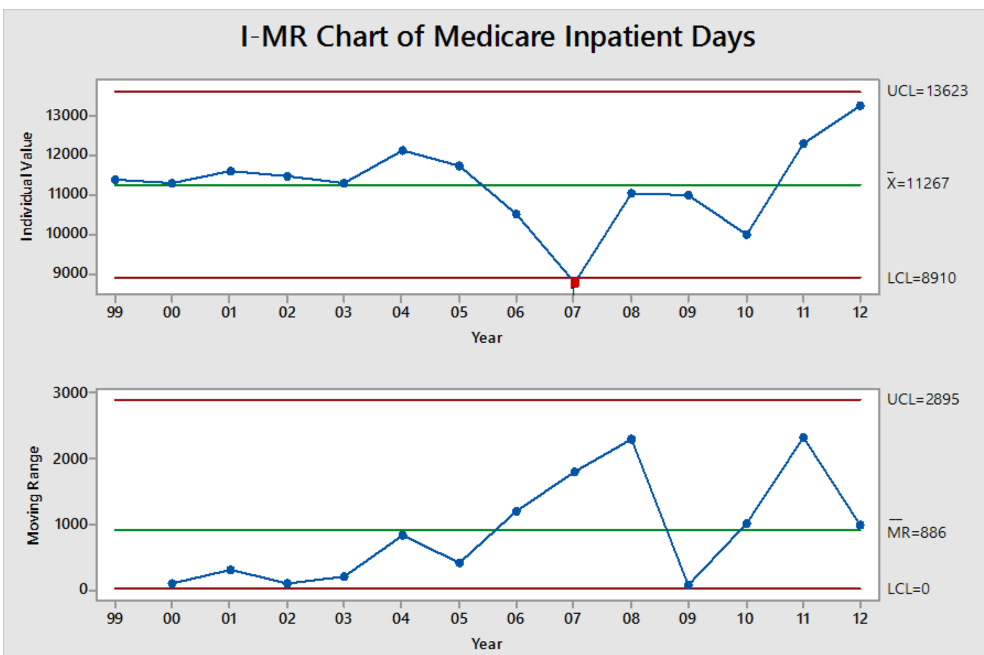

Figure 16: I-MR chart of Medicare inpatient days. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

4.4 Key indicator for average length of stay

This key indicator serves as a generalized measurement for the efficiency of acute and psychiatric care services rendered by the hospital. Since the spread of data is smaller than previous charts in which data points were in the thousands, the first tool to be used will be a run chart. Figure 17: Run chart of average length of stay featured below indicates greater consistency than previous the previous processes. The only point of concern is the year 2010 in which there is a sharp decrease in length of stay by the year 2013.

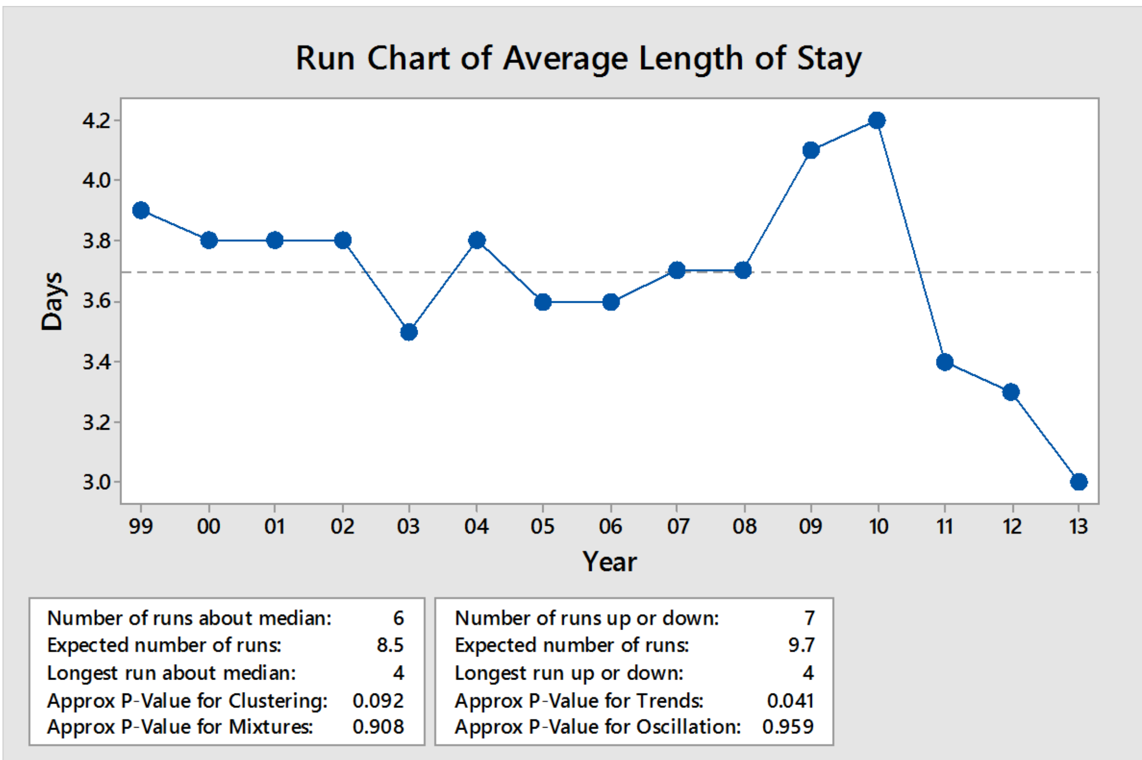

Figure 17: Run chart of average length of stay. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

The variable chart shown below in Figure 18: I-MR chart of average length of stay affirms the need for concern for the years 2010 and 2013 as these two points are out of control. The moving range chart also indicates 2011 is out of control as well. This measure only loses is capability after the year 2009, in which there is significant variation. While the average length of stay only refers the short-term acute and psychiatric care, there is special cause for the variation shown below. As the previous indicator has shown, this measure will also need further investigation into the root causes for variables that are beyond the control limits. However, one assignable cause that could be inferred from the data is a decrease in major surgeries, enabling patients to be discharged from the hospital in a timely manner. This is further cemented by the fact that the number of inpatient surgeries and the length of stay have decreased after the year 2010. A decrease in admissions could have this effect as well, but previous charts have shown a steady increase in admissions since the year 2007.

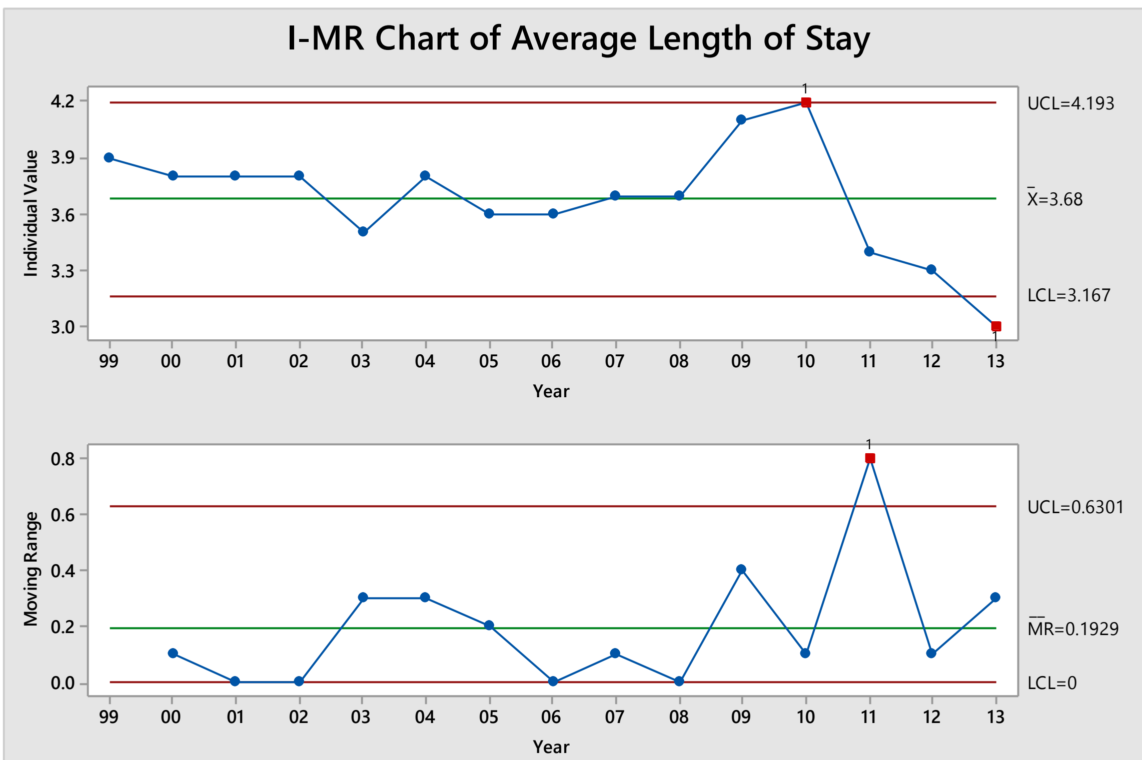

Figure 18: I-MR chart of average length of stay. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

4.4 Key indicator for outpatient visits

Outpatient hospital utilization is as important inpatient utilization. The hospital will need to provide timely and effective care to the community in order to limit the spread of any infections within the hospital. The pie chart shown below in Figure 19: Pie chart of outpatient visits organizes outpatient visits into emergency room and other. Other can also be labeled as non-emergency which accounts for all doctor's appointments. Doctor's appointments account for the majority outpatient visits. However, both categories will be further investigated through the use of run charts and variable charts.

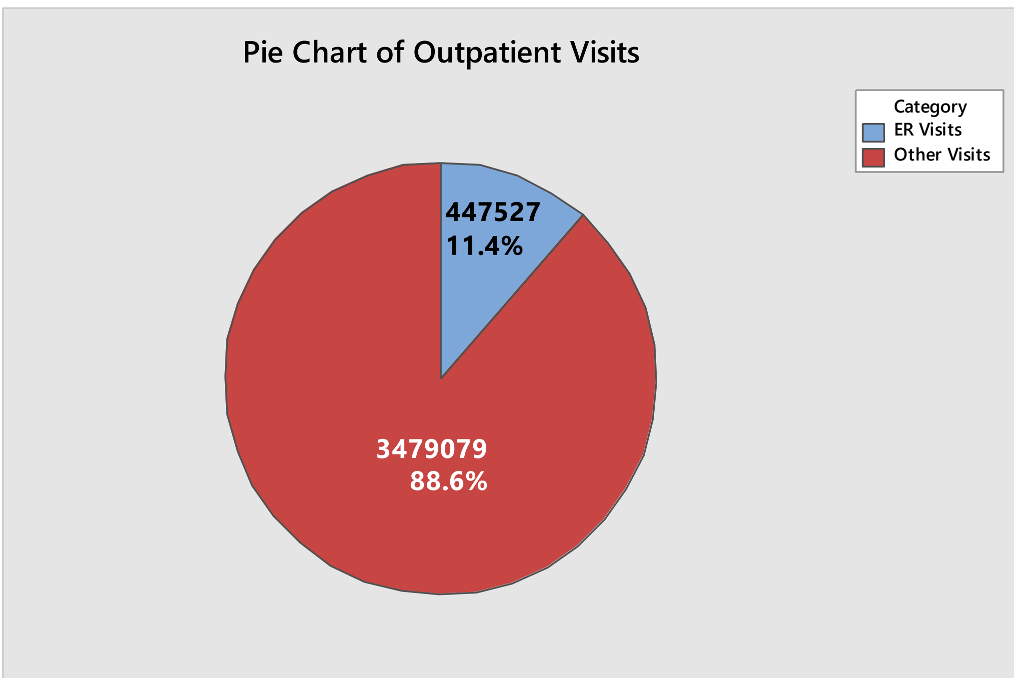

Figure 19: Pie chart of outpatient visits. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

The run chart featured below in Figure 20: Run chart of emergency room visits indicates concerns for several variables. There is significant variation throughout the years with little difference between the years 1999 and 2013. The variables that would be of concern include: 2004, 2007, 2008, and 2012. The lack of consistency is also shown in Figure 21: Run chart of non-emergency visits. However, the trend within this chart is consistently dropping where the data reaches its lowest point in 2009. There is a significantly less number of doctor's visits in 2013 than there is in 1999. There are numerous external factors that could account for unpredictable variation in emergency room visits and a sharp decrease in doctor's visits. The variation is further explored through the use of variable control charts.

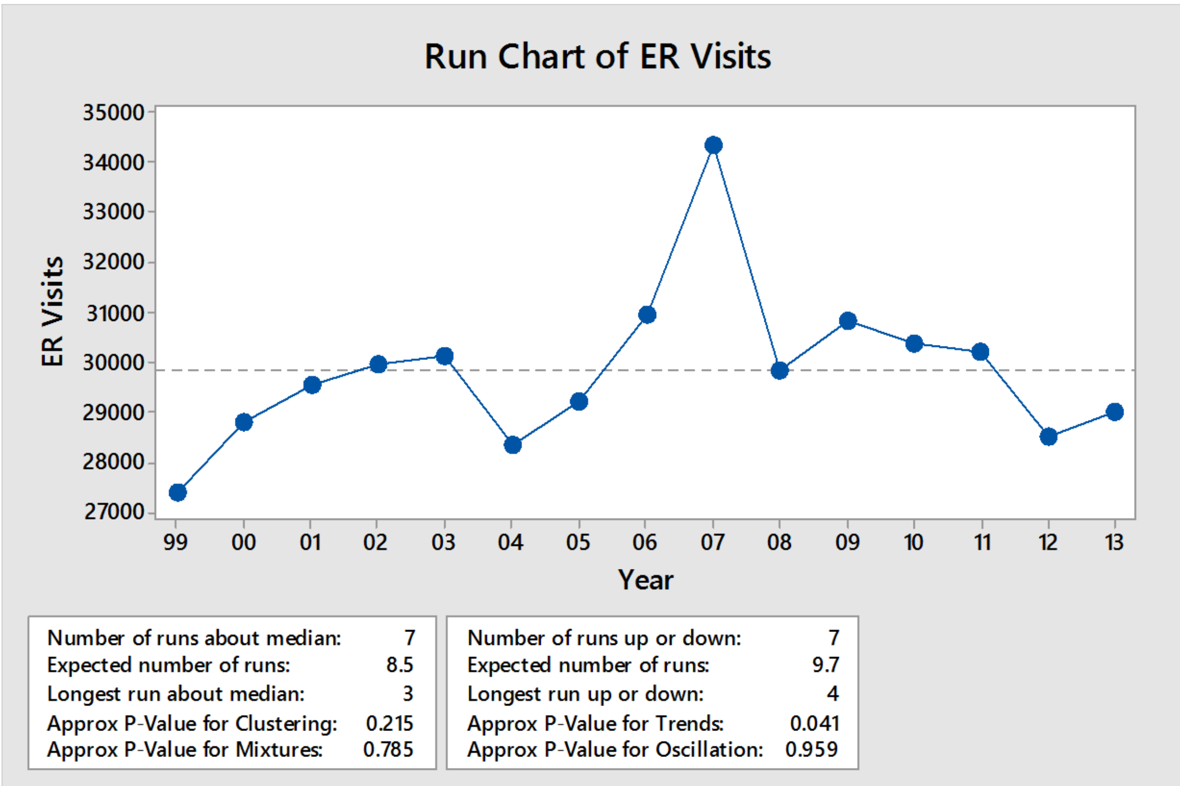

Figure 20: Run chart of emergency room visits. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

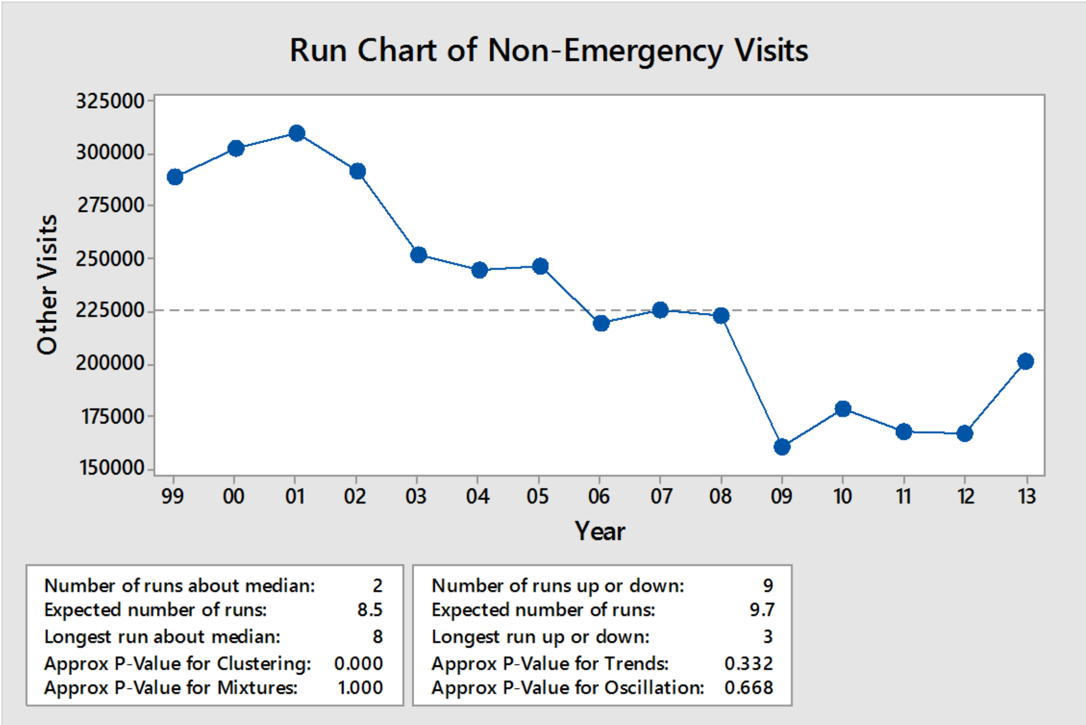

Figure 21: Run chart of non-emergency visits. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

Even though there were several variables that were a cause for concern in the previous run charts, Figure 22: I-MR chart of emergency room visits denotes only one variable that is out of limit in the individuals chart, and again in the moving range chart. While the run chart of non-emergency visits showed a more definite pattern, Figure 23: I-MR chart of non-emergency visits indicates greater process variability with a total of nine variables that are beyond limits. Non-emergency or doctor's office visits has shown the greatest amount of variable in the study. While external human factors cannot be 'fixed,' they can be identified. Further investigation would be recommended to understand the cause for such a decrease in outpatient visits. An investigation could be conducted into the following: utilization of doctors and nurse practitioners, review of census data for the surrounding area, and programs that have been added or removed. Two logical assignable causes that could be derived include: the hospital is outsourcing patients to other care centers, and the hospital may need to provide more support to preventative care services.

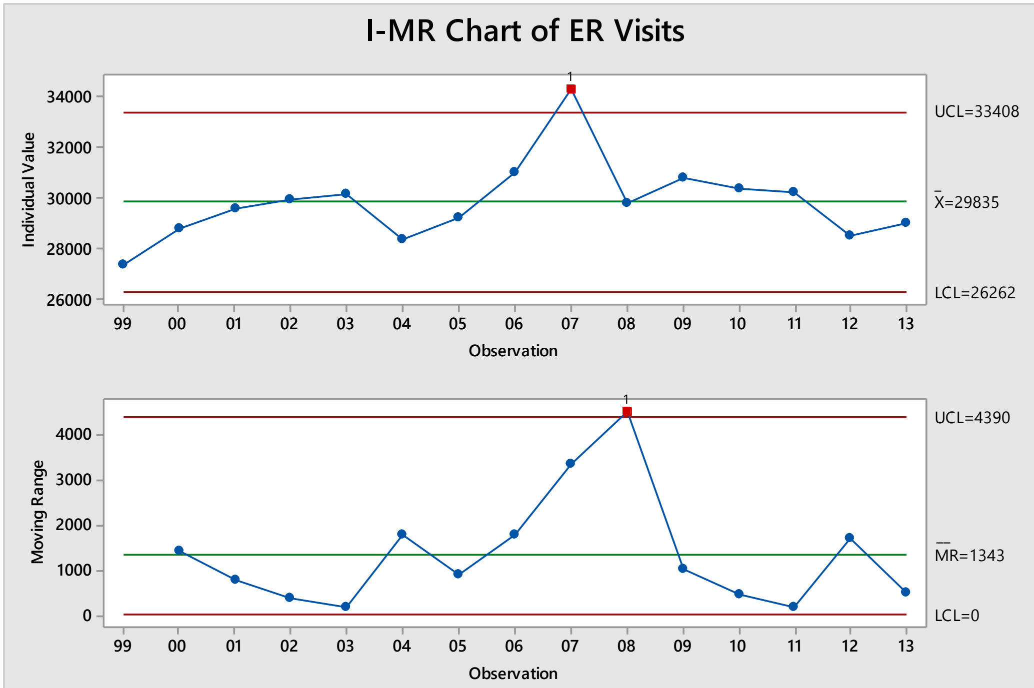

Figure 22: I-MR chart of emergency room visits. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

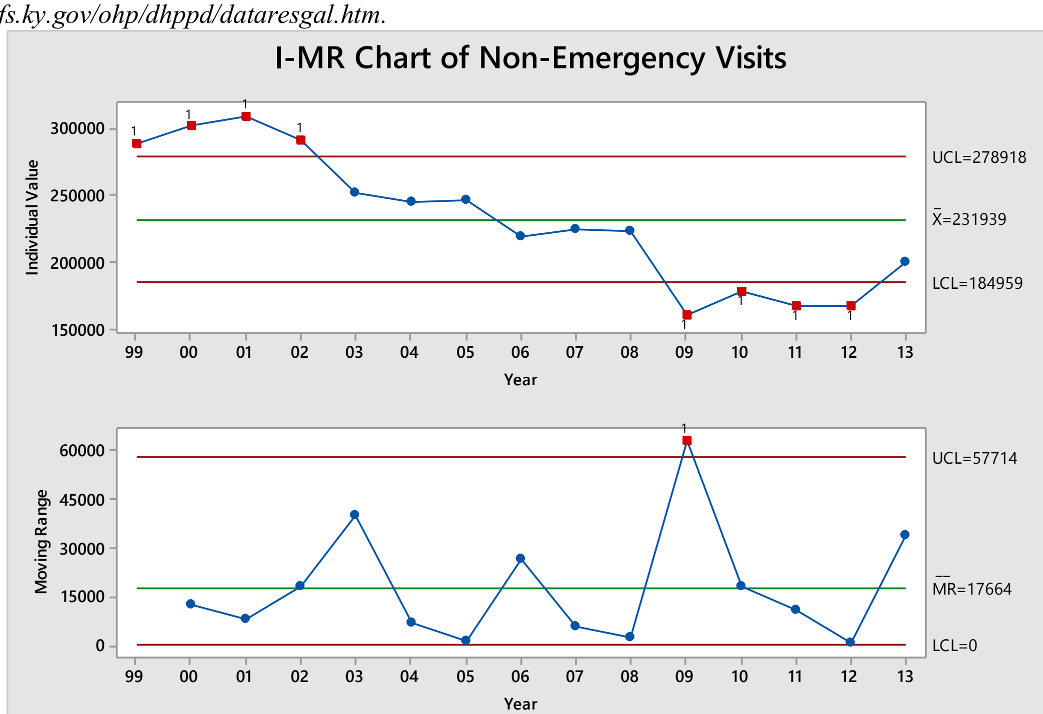

Figure 23: I-MR chart of non-emergency visits. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

4.5 Key indicator for inpatient/outpatient surgeries

This key indicator includes general data for number of inpatient and outpatient surgeries by year. Inpatient surgeries include all inpatients within the facility. Outpatient surgeries are also known as ambulatory surgeries. These minimally invasive surgeries are same day and do not require an overnight hospital stay. As shown in Figure 24: Pie chart of surgeries, the hospital conducts a greater number of ambulatory surgeries. This is further cemented by the fact that the hospital is primarily a short-term acute care hospital.

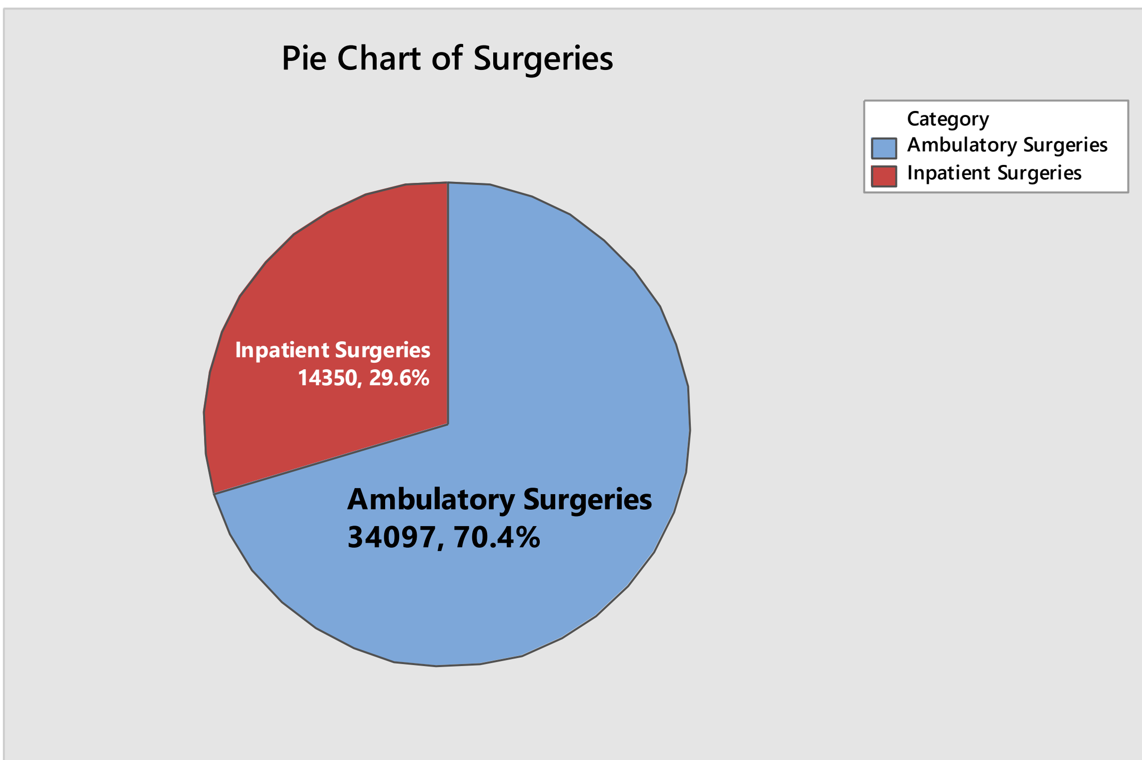

Figure 24: Pie chart of surgeries. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

The spread of the data is further analyzed below in Figure 25: Histogram of inpatient surgeries. The descriptive statistics state the mean is 956.7 and the standard deviation is 52.62. The data is primarily dispersed between 900 and 1,000 operations. There are two outliers to the left, however they do not influence the data since the majority of variables are centered close to the mean. Even though this histogram shows the best fit in the study, it is still a poor fit since there are variables outside of the fit line. Thus, the distribution is also non-normal. However, a greater amount of information could increase the reliability of the measurements and produce a normal curve.

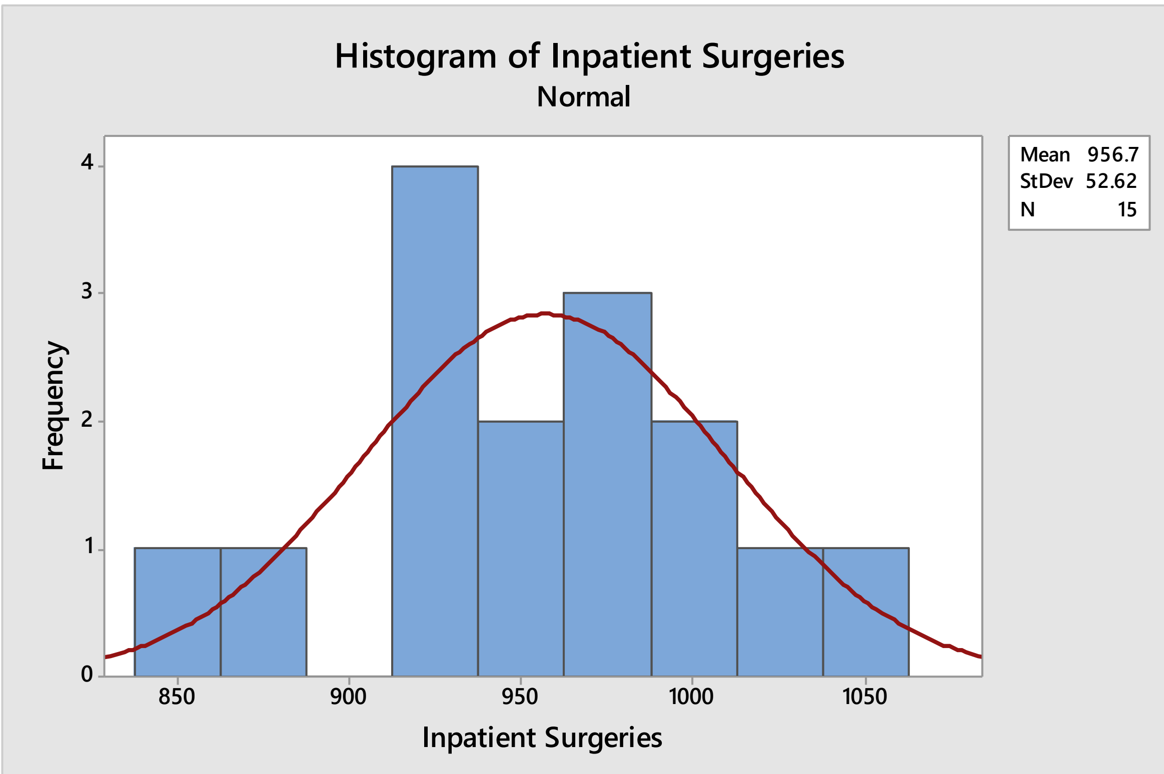

Figure 25: Histogram of inpatient surgeries. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

Figure 26: Run chart of inpatient surgeries shows fairly consistent variation until a sharp decrease after the year of 2010. The only cause of concern in further investigation would be the variable, 2011.

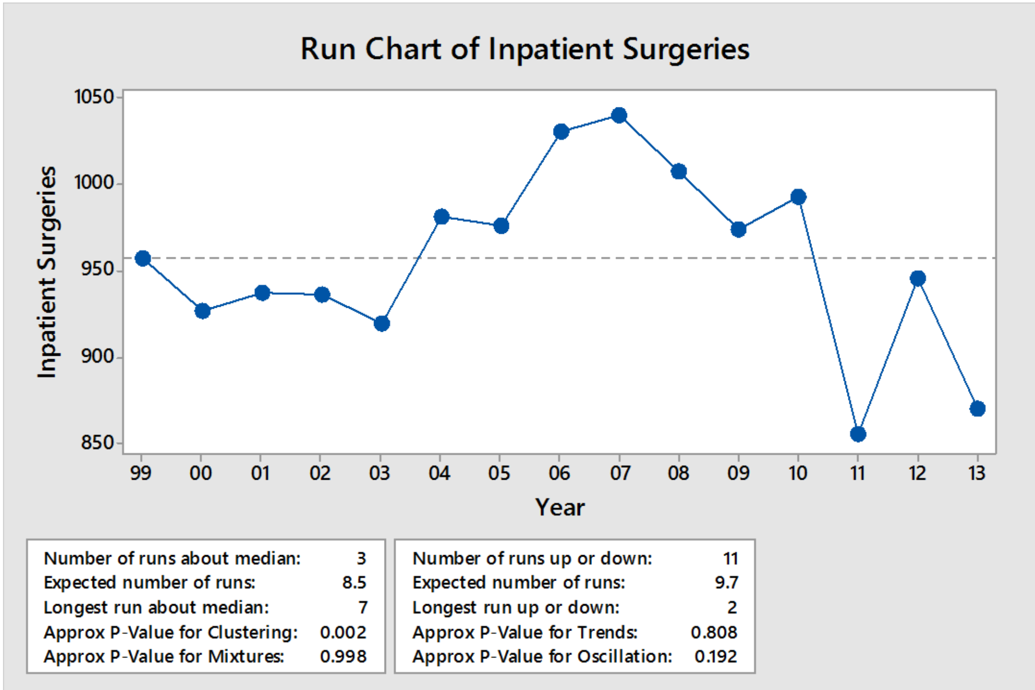

Figure 26: Run chart of inpatient surgeries. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

As seen in Figure 27: I-MR chart of inpatient surgeries, the only cause for concern is still within the UCL and LCL limits. Inpatient surgeries has shown the least amount of process variation since the only point out of control is found in the moving range chart for variable, 2011. This variable is out of control since the difference between 2010 and 2011 is too great for the process the handle. When taking a second look at the previous charts for other key indicators, the following was found for the year 2010:

- Lower emergency room and non-emergency visits.
- Considerable decrease in average length of stay.
- Same variable is out of control in I-MR chart for admissions.

The decrease in inpatient admissions, outpatient visits, and average length of stay most likely led to the large difference between 2010 and 2011, causing the data point to go out of control in Figure 27: I-MR chart for inpatient surgeries.

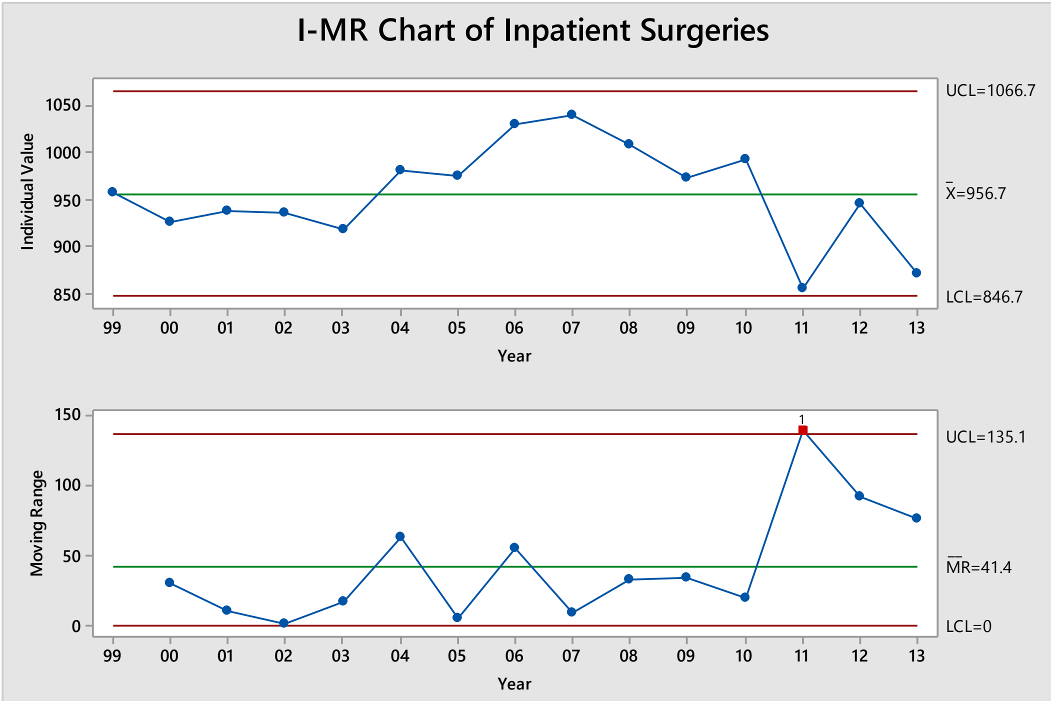

Figure 27: I-MR chart of inpatient surgeries. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

The last data set to be measured and analyzed is ambulatory surgeries. As described previously for inpatient surgeries, lower emergency room and non-emergency visits were some of the variables identified that could have caused a decrease in inpatient surgeries. However, the opposite is true of outpatient surgeries, which may yield yet another possible conclusion. As shown below, Figure 28: Histogram of ambulatory surgeries lists a mean of 2273 procedures with a standard deviation of 672. The data is primarily dispersed between 1,500 and 2,500. The outliers around 3,500 could have some influence on the mean since it seems a little high considering the highest frequencies occur between 1,500 and 2,000. In addition, the fit line indicates another non-normal distribution since the data is a poor fit. The bars indicating the data points all lay outside of the fit-line with the exception of one. The dispersion of the data indicates future variability in other charts.

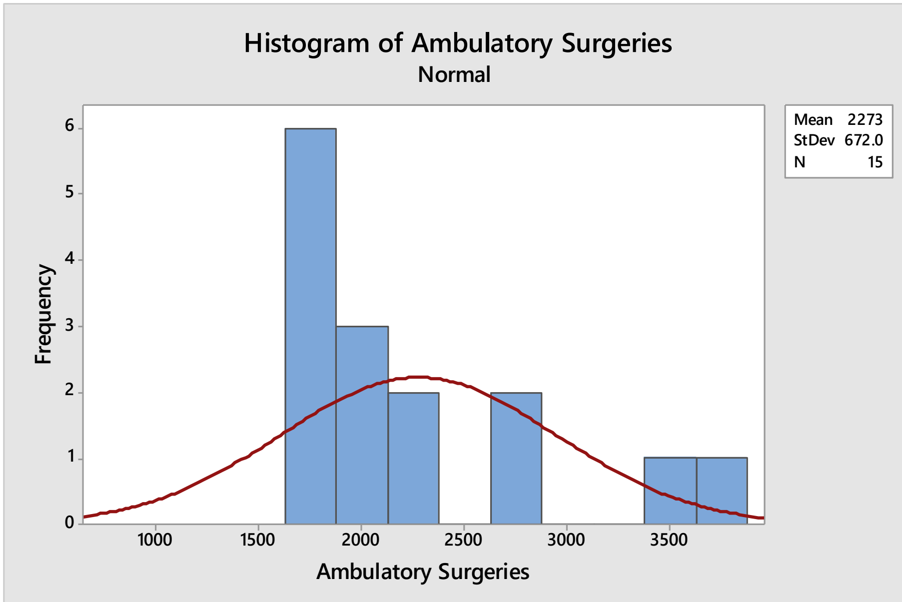

Figure 28: Histogram of ambulatory surgeries. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

Figure 29: Run chart of ambulatory surgeries indicates several points of concern for years 2000, 2001, and the sudden decrease leading to 2002. However, the majority of the chart shows a consistent, upward progression of outpatient surgeries.

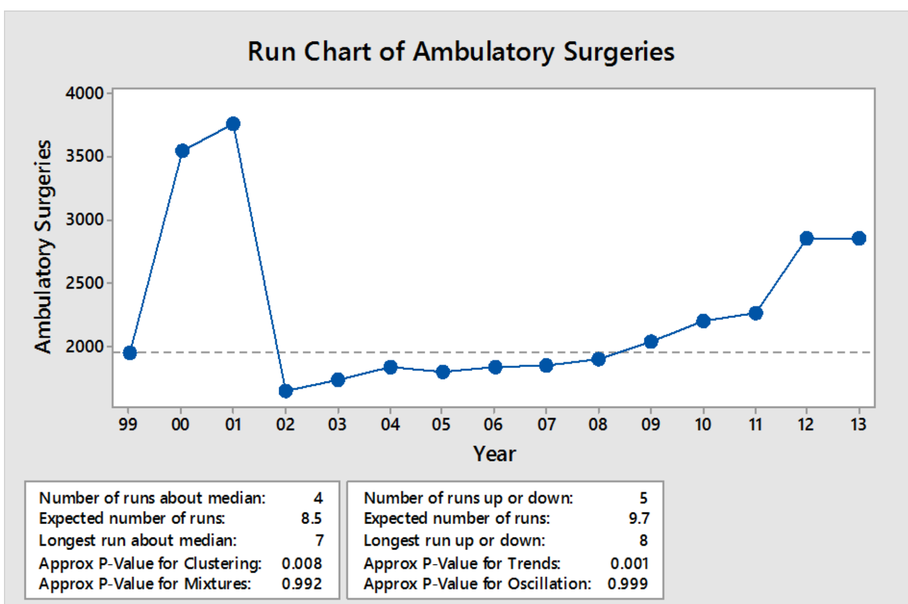

Figure 29: Run chart of ambulatory surgeries. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

As shown below in Figure 30: I-MR chart of ambulatory surgeries, two of the three points of concern are beyond limits. Two more points are shown as out of limits as well in the moving range chart. While there was extreme variability previously, the current trend seems largely seems to be in control. Some assignable causes that could be attributed to this variation include: lower demand for ambulatory surgeries, and the outsourcing of patients to other care providers.

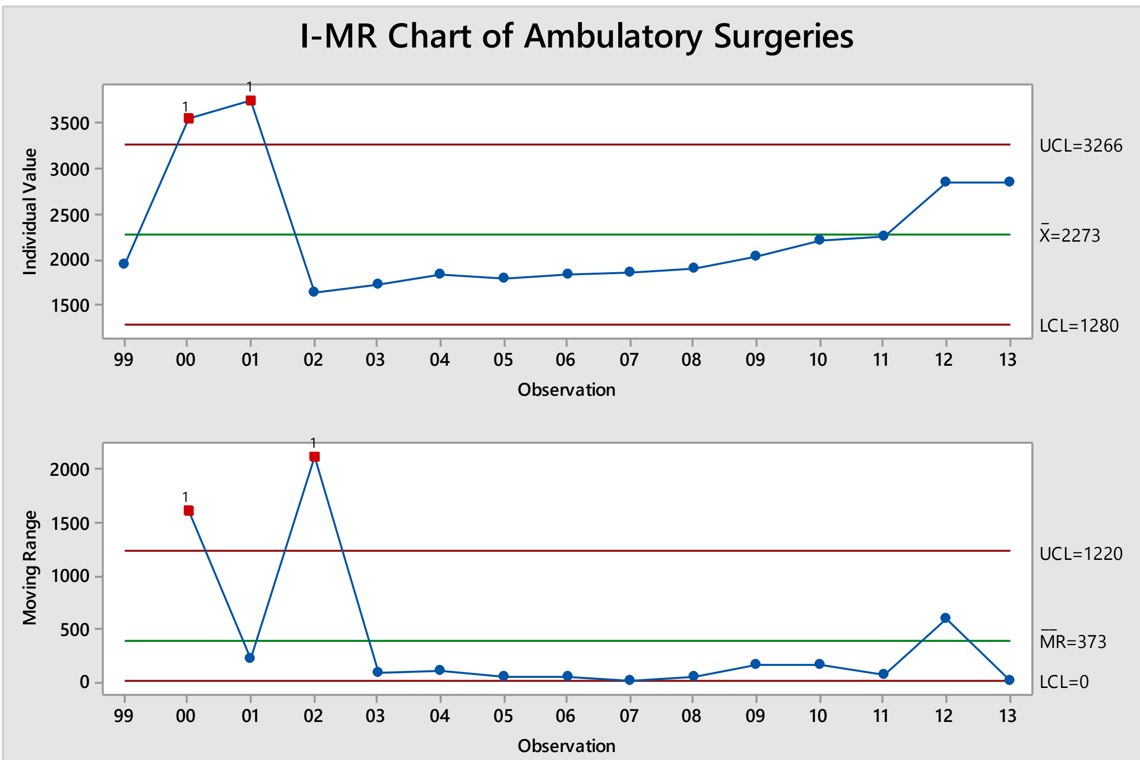

Figure 30: I-MR chart of ambulatory surgeries. Chart constructed in Minitab 17 software program by author. Data retrieved from: Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

4.6 Summary and recommendations

Quality improvement began with major inventions that spurred massive changes within industrial manufacturing. By the 1970s, business were beginning to adopt quality assurance programs in efforts to utilized quality improvement as a prevention method. The need to establish standards in the 1980s resultred in the creation of Total Quality Management, ISO 9000 (later 9001), Six Sigma, and Lean Six Sigma. Since this revolution, quality management in healthcare has evolved to organizational-wide involvement monitored by numerous accreditation agencies, laws, patient safety committees, and other quality control organizations. Barrick (2009) describes the need for quality management as,"report cards for public knowledge, competitive advantage, accreditation requirements, customer satisfaction, and economic viability." The application of quality management within the healthcare industry is both a broad topic and is considered a recent evolution within the last twenty years.

The primary goal of this research was to create an all-encompassing resource identifying specific quality systems that are applicable to the healthcare industry, providing examples of application, and provide a time study of major processes that enable a hospital to function. The name of the facility was omitted from the research since the appropriate permission to publish the name was not granted. Therefore, the research simply became an exploration of healthcare quality systems. The research follows Six Sigma thinking since the information was defined, measured, analyzed, improved, and controlled through the use of the research objectives.

Data for the facility was collected from the Annual Hospital Utilization and Services Report for years 1999- 2013 and the Annual Administrative Claims Data Report for years 2008-2012 (Data Resource Gallery, 2014). The Annual Hospital Utilization and Services Report is published by the state. The main limitation for this data was it was published by a government source which creates bias in the information. This limits the internal validity of the research since the government sources cannot be completely verified for accuracy.

Five key indicators were selected to measure, analyze, improve, and control the hospital's performance measures. The key indicators included: admissions, inpatient days, average length of stay, outpatient visits, and inpatient surgeries. These key indicators feature both internal and external measures. The findings focused on improve and control through the use of control charts and possible assignable causes and recommendations for the research.

Following the use of pie charts, Pareto charts, and variable MI-R charts, there were several points that were beyond limits. However, a big picture perspective realizes that each set of data points had a fourteen year range. One or two data points that are out of limits in a fourteen year timeline is not a major concern. The indicator with the least variability was inpatient surgeries with only one data point that was out of limit. A summary of the assignable causes inferred from the data includes: the hospital may not have acute beds in operation to meet rising admission rates. This is shown in the table featured in Appendix B, where the number of acute and psychiatric care beds have remained the same for fifteen years; the hospital may be outsourcing patients to other providers and/ or medical centers due to decreases in length of stay, inpatient surgeries, and doctor's appointments; the hospital may need to increase support for preventative care services due to decreases in doctor's visits and an increase in ambulatory or same-day surgeries.

While there were some notable findings, much of the data is generalized information about the hospital's primary functions. Additional data for each key indicator would produce greater results in problem solving tools and statistical process control tools such as control charts. This would have the most effect on average length of stay, and inpatient days since these indicators act more as performance measures rather than processes. Measurement of the finer processes for admissions, inpatient/outpatient surgeries, and inpatient visits would yield more definitive results. This would make problem solving opportunities more effective since smaller, defined processes will provide more information as to where the problem is occurring and why.

The primary recommendation for this facility would be to incorporate Lean Six Sigma thinking and problem solving tools to identify internal and external influences for the key indicators. The data used has a range of fourteen years. There is much to be learned from the past and further investigation could produce information that would be viable for future process improvement opportunities. Lean Six Sigma thinking refers to the method of problem solving using the Plan, Do, Study, Act cycle. This method of identifying the need for improvement, collection and analysis of the data, and action plans for improvement and monitoring will provide the guidance and tools necessary for improvement. The most useful tool based on the data provided would be the root cause analysis or fishbone diagram discussed in Chapter 2 under the topic of problem solving tools. This tool is frequently used to understand the surface problems leading to the root of a problem in order to stop the occurrence of variation within the data. Much of the data presented in the findings did not necessarily indicate problems. However, a root cause analysis could also be utilized to identify the factors influencing the variation.

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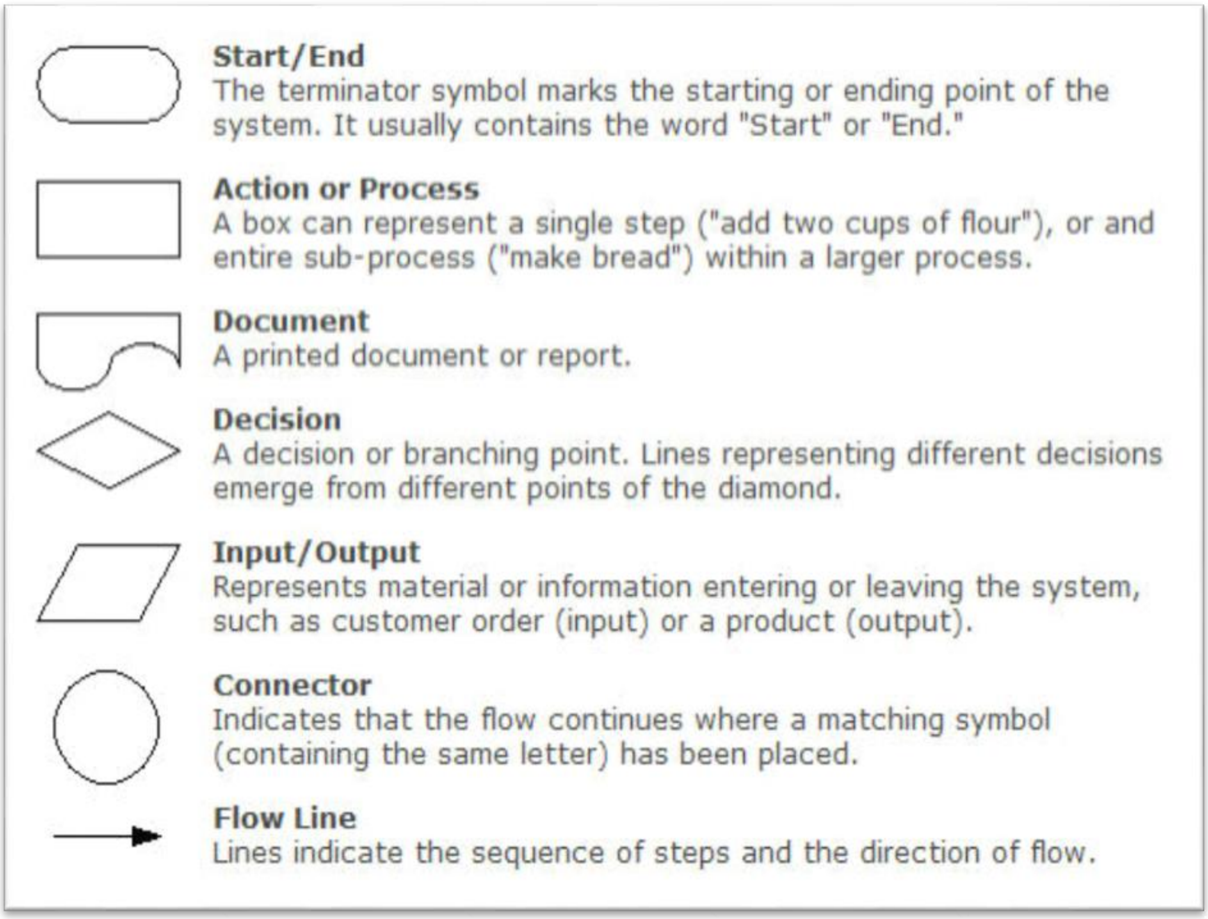
Appendix

Appendix A: Flow chart shapes and definitions



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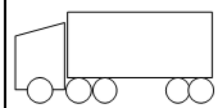
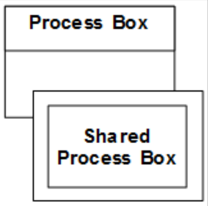
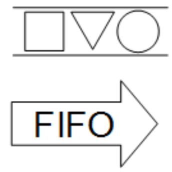
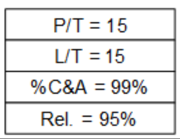
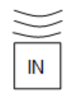
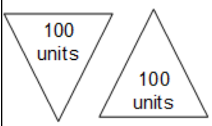
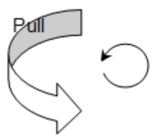
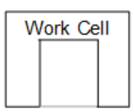
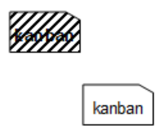
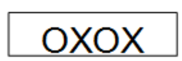
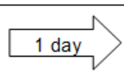
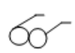
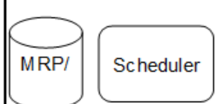
Retrieved from: Broughton, R. (n.d.). Flowchart shapes and description. Retrieved April 4, 2015, from http://www.quality-assurance-solutions.com/flowchart-shapes.html.

Appendix B: Value stream map shapes and definitions

Symbols	Description	Symbols	Description	Symbols	Description
	**Customer/ Supplier** Start or end point for material flow		**Kaizen Blitz** Area for Improvement		**External Shipment** Shipments to or from suppliers
	**Process** Machine, operation or department through which material flows		**Supermarket** Small inventory for immediate production		**FIFO** First in, First out lane
	**Data Box**		**Buffer** Safety Stock		**In Box** Information Queues
	**Inventory**		**Pull Symbols** Replenish stock in supermarket		**Internal Movement**
	**Work Cell**		**Kanban Card** Replenish stock in supermarket		**People, phones, operators, etc.**
	**Push Arrow**		**Load Leveling**		
	**NVA Delay**		**Go and See** When there is a problem, go and see what's wrong.		**Scheduling**

Retrieved from: John D. Dingell VA Medical Center, Detroit, Michigan. (n.d.). Retrieved April 10, 2015, from http://www.detroit.va.gov.

Appendix C: Data organization for inpatient utilization

Inpatient Utilization										
Year	Beds in Operation			Admissions	Discharges	Inpatient Days				Average Length of Stay
	Acute	Psych	Total	Total	Total	Medicare	Medicaid	Total	Other	
1999	119	20	139	5,020	4,999	11,400	4,252	19,695	4,043	3.9
2000	119	20	139	5,088	5,110	11,301	4,308	19,326	3,717	3.8
2001	119	20	139	5,430	5,417	11,585	4,588	20,669	4,496	3.8
2002	119	20	139	5,683	5,683	11,491	5,002	21,887	5,394	3.8
2003	119	20	139	5,834	5,839	11,297	5,148	22,302	5,857	3.5
2004	119	20	139	5,155	5,182	12,114	5,532	19,788	2,142	3.8
2005	119	20	139	5,094	5,098	11,714	4,754	18,274	1,806	3.6
2006	119	20	139	5,094	5,085	10,528	4,423	18,133	3,182	3.6
2007	119	20	139	5,181	5,171	8,749	3,421	19,289	7,119	3.7
2008	119	20	139	5,644	5,650	11,046	4,597	20,817	5,174	3.7
2009	119	20	139	5,729	5,753	10,977	4,539	23,610	8,094	4.1
2010	119	20	139	6,466	6,460	9,972	4,291	27,550	13,287	4.2
2011	119	20	139	6,330	6,327	12,289	3,945	21,691	5,457	3.4
2012	119	20	139	6,110	6,027	13,268	4,120	21,825	4,437	3.3
2013	119	20	139	6,701	6,666	Not Available	Not Available	18,460	Not Available	3.0

Table composed by author using MS Excel software. Data retrieved from Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.

Appendix D: Data organization for outpatient utilization

Outpatient Utilization						
Year	ER Visits	Other Visits	Total Visits	Inpatient Surgeries	Ambulatory Surgeries	Total Surgeries - Inpatient/Outpatient
1999	27,384	289,531	316,915	957	1,948	2,905
2000	28,789	302,241	331,030	927	3,557	4,484
2001	29,572	310,061	339,633	937	3,767	4,704
2002	29,954	291,898	321,852	936	1,648	2,584
2003	30,129	251,934	282,063	919	1,736	2,655
2004	28,342	245,115	273,457	981	1,838	2,819
2005	29,226	246,306	275,532	976	1,797	2,773
2006	30,979	219,678	250,657	1,031	1,838	2,869
2007	34,332	225,360	259,692	1,040	1,850	2,890
2008	29,827	223,085	252,912	1,008	1,897	2,905
2009	30,833	160,144	190,977	974	2,044	3,018
2010	30,394	178,241	208,635	993	2,208	3,201
2011	30,221	167,586	197,807	855	2,262	3,117
2012	28,534	167,044	195,578	946	2,851	3,797
2013	29,011	200,855	229,866	870	2,856	870

Table composed by author using MS Excel software. Data retrieved from Data Resource Gallery. (2014, November 11). Retrieved April 10, 2015, from http://chfs.ky.gov/ohp/dhppd/dataresgal.htm.