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Term Project:

COMBINING DMAIC AND PDCA: A METHODOLOGY TO REDUCE ED WAITING TIME

Course: SSIE 537

Industrial and Systems Engineering in Health Care

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INTRODUCTION

Background

Emergency departments (ED) are well known for having long waiting times and being crowded. It is no surprise that long ED waiting times lead to unfavorable consequences in regard to patient safety. However, patient safety is certainly not the only negative consequence of ED overcrowding and lengthy waiting times. Lately, hospitals are competing for patients by advertising their current average time spent in the waiting room. The reduction of crowding and prolonged wait times in emergency rooms is being studied and explored all over the world. This major problem has been acknowledged by major healthcare organizations as a priority in process and performance improvement. Determining the causes of overcrowding and extended waiting times is crucial to investigating how to correct them.

ED overcrowding and prolonged waiting times are caused by a wide variety of factors. One factor, studies show, is that demand for emergency departments has rapidly over the last twenty years. In fact, from 1995 to 2005, the annual number of visits to EDs in the United States increased from 96.5 million to 115.3 million per year – a 20% increase (Moskop, 2009). These increases in visits are likely due to in the increase in population size of the US, which is a result of immigration and improvements in technology that lead to a longer lifespan (Moskop, 2009). However, while the population has been increasing, the number of hospitals has not increased at the same rate to match the population. In fact, the number of hospitals in the US actually decreased by 535 during those same ten years (Moskop). The closing of these facilities are linked to financial pressures placed on hospitals regarding cuts in private and public insurance reimbursement, as well as an unfunded federal mandate known as the Emergency Medical Treatment and Active Labor Act (EMTALA), which was passed in the late 1980's (Moskop, 2009). Another major cause for ED overcrowding, in addition to increased demand, is the lack of hospital beds (McCabe). Often, patients that come to the ED are then admitted to the hospital, but because of the lack of beds, they are stuck waiting in the ED. The issue of long waiting times and overcrowding in the ED has been around for dozens of years, and is still a growing problem.

In fact, many times, patients are so dissatisfied with the extended wait times that they leave the ED without being seen. Additionally, this is not a recent phenomenon. In 1997, the Journal of Emergency Medicine published an article noting that up to 15% of ED patients leave without being seen, and when surveyed about why the left, the chief complaint was dissatisfaction with the length of wait (Fernandes, 1997).

Motivation

The most evident negative result from ED wait times is the negative impact on patients' health. However, there are a significant number of other negative consequences operationally and logistically, as well as ethically. ED overcrowding can lead to difficulty in protecting patient privacy and confidentiality (Moskop, 2009). ED overcrowding also makes it difficult to deliver patient-centered care, which should always be the number one priority in any health care facility (Moskop, 2009). Bioethics, the study of medically controversial issues, is an important principle to keep in mind. Typically, the bioethics framework includes four important clusters of fundamental moral principles (Moskop, 2009). The four clusters are no maleficence, beneficence, respect for autonomy, and justice (Moskop, 2009). Nonmaleficence, the cluster best known for its phrase, *"prinum non necere,"* which means "above all, do no harm" (Moskop). Unfortunately, ED overcrowding poses unintended risks of harm, mainly through the form of sentinel events (Moskop, 2009). The Joint Commission defines sentinel events as "unexpected occurrences involving death or serious physical or psychological injury, or the risk thereof" (Joint Commission, 2002). Studies actually show that there is a significant connection between increased inpatient mortality and ED overcrowding (Sprivulus, 2006).

Design scope of problem

The paper is organized as follows: a review of literature regarding emergency department overcrowding and extended wait times is given in Section 2. The methodology adopted for modeling and simulation is explained in Section 3.

The DMAIC methodology, which stands for Design, Measure, Analyze, Improve, Control, is a technique that comes from Six Sigma. Most often, Six Sigma is used in services that need to reduce the number of "defects" that their processes are producing. By considering a sentinel event a defect, the use of DMAIC in improving emergency department is not only appropriate, but pragmatic. In Six Sigma, the performance of any process is measured using CTQs (critical to quality) parameters.

Problem statement

Our goal in this project is to measure the efficiency of the emergency department by quantifying patients' experiences with crowding and waiting times. Therefore, our CTQs in this project will be 1) timeliness of service, 2) wait times, and 3) bed availability in emergency departments and hospitals.

Objective

Therefore, the objective of this paper is to use the DMAIC Six Sigma methodology to propose a framework for improving ED throughput and reduce crowding and long wait times.

LITERATURE REVIEW

History of Six Sigma in Healthcare

The first documented use of Six Sigma in healthcare in the United States was at the Commonwealth Health Corporation in Massachusetts in 1998 (Thomerson, 2001). This groundbreaking case study resulted in a 21.5% reduction in costs and a 33% increase in radiology throughput for the hospital; as a result, hospitals and other healthcare organizations have increasingly begun to use Six Sigma to improve healthcare processes (Thomerson, 2001). One of the next wildly successful Six Sigma projects in healthcare that got public attention was at Mount Carmel Health System in Columbus, Ohio. The 3-hospital system was encountering serious financial problems and included all departments to participate in the Six Sigma project in order to tackle business and financial problems (SeWail & DeYoung, 2003). In just two years, Mount Carmel has used Six Sigma to "enhance clinical documentation to make sure it matches the services rendered, decrease processing time in central scheduling, decrease the number of claims denials due to patient type changes and long-stay observations, discharging throughput to decrease bottlenecks in the emergency department," just to name a few (SeWail & DeYoung, 2003). The success of the program is summarized by one result (among many); just two years after the implementation of Six Sigma initiatives, the Mount Carmel Health System increased their financial return by $3.1 million dollars (SeWail & DeYoung, 2003).

In the last five years, the use of Six Sigma in healthcare has become increasingly popular. In 2013, Antony et. al published the results of a case study in Leadership in Health Services Journal in which they used Lean Six Sigma methodology to reduce waiting time in a pathology department. The data for the study came from a super-specialty hospital attached to a manufacturing company (Antony et. al, 2013). Prior to the project, an average waiting time of 24 minutes per patient was observed, with a standard deviation of 17.5 minutes (Antony et. al, 2013). Antony et. al decided to use the DMAIC methodology because they felt that in order to properly reduce this, they needed to fully comprehend the reasons behind such unreasonable wait times as well as the root causes for the high variation in waiting times. Throughout the study, the number of non-value-adding activities was found to be very high. Through the use of box plot, dot plot, and hypothesis testing using Minitab, Antony et. al successfully identified and took measures to correct these unacceptable waiting times. The results of the project caused the waiting time to go from an average of 24 minutes to an average of 11 minutes per patient, and the variation to go from 17.5 minutes to 10.04 minutes (Antony et. al, 2013). That same year, the journal published another case study of the results of using Lean Six Sigma techniques in an large, semi-urban Irish hospital (Antony, Brady, Laureani, 2013). This study presented the results of five process improvement projects by Masters' students for a class on operations and quality management. Six Sigma was the main methodology used in only one of the five projects. Although the students were relatively new users of Lean Six Sigma and the project only lasted approximately three months, the results yielded beneficial and practical to the hospital in a variety of settings. The project which used solely the Six Sigma DMAIC methodology was carried out in the department which handles medical records as a result of observing medical records being unavailable and un-locatable before surgery, which sometimes led to cancellation of the surgery (Antony, Brady, Laureani, 2013). The main supporting techniques used were checklists, TOC, and logic trees. The students carefully chose techniques for each phase of DMAIC; for example, the use of the theory of constraints used in the Define phase resulted in the identification of bottlenecks and main blockages in the process. Prior to the project, the hospital was experiencing approximately a 31% "defect" rate (i.e. 31 percent of the time, medical records were unavailable at the scheduled time for surgery) (Antony, Brady, Laureani, 2013). After the project, however, that percentage dropped to less than 3% (Antony, Brady, Laureani, 2013). This extremely successful case study highlights the benefits of using DMAIC to improve healthcare processes.

Causes of ED crowding

In 2008, researchers from the Department of Biomedical Informatics and the Department of Emergency Medicine at Vanderbilt University Medical Center conducted a comprehensive literature review to determine causes, effects, and solutions to emergency department crowding (Hoot & Aronsky, 2008). Various causes were studied, and three main themes were discovered: input factors, throughput factors, and output factors.

The first theme, Input factors, considers ED crowding causes related to patient inflow. Some identified causes for increased patient inflow are environmental, such as influenza season. Although this is clearly a seasonal problem that will fluctuate on its own accord, it still has significant impacts during those weeks. For example, in Los Angeles, results

of a study in local county hospitals indicated that for the peak flu month of the year, visits to the ED increased by 4 to 7 times the visits for the rest of the year. Another significant cause related to inpatient flow was the lack of a primary care doctor; these patients came to the ED often for nonurgent reasons are colloquially called "frequent-flyer" patients. According to the analysis, these visits account for almost 15% of total visits to the emergency department.

Throughput factors, the second theme, were related to identify bottlenecks in the ED. The main identified cause of ED crowding that is a throughput factor was insufficient staffing. One study found that an ED nurse was responsible for 4 patients at a time, and an ED physician was responsible for 10 patients at a time. Finally, the use of technology and machines that have long processing times, such as CT scans, accounted for extended wait times of patients.

Lastly, the output factors were related to bottlenecks in departments other than the ED, such as hospital bed shortages. As the occupancy level of the hospital increased, so did the mean length of stay. A notable study indicated that one hospital whose occupancy level reached 90% resulted in a substantial increase in the rate of severe crowding.

Effects of ED crowding

It is no surprise that emergency department crowding has negative impacts on patient health. Simply, the amount of resources in the ED is not enough to support the number of patients. Results show that ED crowding leads to a higher rate of patient mortality as well as decreased quality of care (Bernstein et al., 2009; Pines et al., 2011). Literature reviews done in the last five years have also encountered numerous studies that have linked ED crowding with delayed administration of analgesia and antibiotics (Bernstein et al., 2009; Johnson & Winkelman, 2011).

In 2014, a systematic review was conducted to compare various journals, articles, and studies conducted about ED crowding and adverse patient outcomes. Of the eleven articles searched, the review found that five of these articles stated that ED crowding leads to an increase in the rate of balking patients.(Carter, E. J., Pouch, S. M., & Larson, E. L., 2014). A research article that conducted a study on 127 patients that left the hospital without being seen (LWBS) and found that over 75% of the patients that left did so because of the extended wait time (Johnson, et al., 2009). The actual mean waiting time for these patients was 70.4 minutes. An interesting result that came from this study was that almost 50% of those patients declared that they would have stayed in the hospital and waited longer if the ED provided them with some "comfort measures," which included lab testing, x-rays, analgesics and information. The study observed 11,147 patients and 127 patients left without being seen, which is 1.1% (Johnson, et al., 2009). However, that represents about 1.1 million patients who leave emergency departments in America per year, which is quite a staggering number.

Several of the most prominent effects of ED crowding were "patient mortality, treatment delays, transport delays, ambulance diversion, patient elopement, and financial effect." Lastly, numerous solutions were studied, some of which were "additional personnel, observation units, hospital bed access, non-urgent referrals, ambulance diversion, destination control, crowding measures, and queuing theory." This comprehensive study

Solutions to ED crowding

Earlier this year, a report was published in Socio-Economic Planning Sciences Journal that evaluates results of different strategies using agent-based simulation modeling to reduce waiting time in the ED (Kaushal, et al., 2015). One of the strategies proposed was a modification of the ED floorplan; the idea behind this strategy is to improve patient flow by adding resources, which would hopefully reduce bottlenecks. Additionally, there are other ways to modify the floorplan without getting additional resources, such as creating a small area where stabilized ED patients can be placed in order to free up more beds. Another suggested strategy was to use human resources to maximize staff utilization. By observing the highest "rush" times, human resources could change the schedule to add more staff when there are historically more patients entering the system. Another strategy suggested is a concept called considering the "inner role" of ED staff. By assessing each staff member and identifying personal strengths and weaknesses, each staff member can be assigned directly to jobs that match their abilities. In this strategy, the idea is that only when the ED becomes extremely busy, staff members begin to take on other jobs. The best example of this would be keeping senior physicians consistently for high-risk surgeries, problems, and diagnoses, "rather than on basic procedures that other staff are able to perform."

Methodology

Define

In the define phase of DMAIC, main objective is to define the main goals and objectives of the project which is going to be done [1]. In this stage, customer's expectations, deliverables, process map, and voice of the customer is identified. There are several different tools that can be used in the Define phase of DMAIC such as project charter, SIPOC diagram, process map, Critical to Quality (CTQ) diagram, and Voice of the Customer (VOC) [1]. For the purpose of this project, we decided to prepare a project charter that includes the title of the project, project start date and estimated

ending date, problem statement, objectives, goals and scopes, expectations, members and project manager, tools that will be used, necessary budget, timeline of the project, and finally a background to the project.

Main goal of the project is to implement Six Sigma DMAIC methodology to reduce the patient waiting time at the emergency departments and also other objectives have been discussed with more details in previous sections.

Project Charter			
Project Name	**Using Six Sigma DMAIC to Reduce Patient Waiting Time in Emergency Departments**		
Organization	**XYZ Hospital**		
Project Manager	**Dr. Mohammad Khasawneh**		
Project Team Members	Mohammad Al-Mashraie Ashley Holmes Mohammad Sadegh Mikaeili		
Project Background	One of the significant sources of incurred healthcare costs are occurring in emergency department units and this affects effectivity, efficiency, quality and accessibility of service. One of the attributes that can decrease the efficiency and effectiveness of ED is the increasing rate of patient waiting time. Given this background, in this project the team tries to use Six Sigma DMAIC methodology to propose a process improvement procedure.		
Expected Business Benefits	Results of this project is not only beneficial for the patients and staff, but also for the high rank managers of the organization. Reducing patient waiting time increases efficiency, effectiveness, and patient satisfaction which will result in higher rate of financial benefits and the hospital can gain more attention from market.		
Proposed Start Date	05/09/2015	**Expected End Date**	12/09/2015
Methodology / Approach/ Tools	Six Sigma DMAIC Framework tools: Root cause analysis, cause and effect diagram, Design of Experiments, Control Charts, SPC tools, Simulation of the current and improved state of the system		
Project Scope	Scope of this project is not only decreasing the waiting time, but to establish a framework which can be used for continuous process improvement for the ED in order to improve performance measures such as effectiveness and efficiency by reducing defects such as patient waiting time. If successfully implemented, necessary changes can be applied to other units in a hospital setting such as operation room and pharmacy.		
Success Criteria (Milestones)	Reducing Patient Waiting Time Increase Customer Satisfaction Increase Processing Time Eliminating Bottlenecks		
Next Meeting's Agenda	Reviewing the results after implementing the first phase of the project. Receiving feedback from managers and shareholders about the outcome of first phase Make necessary alterations to project objectives		
Signature and Date			

It is necessary to mention that project charters must be reviewed and revised after each DMIAC stage and after implementing every change. This has special benefits because it allows the members to review the project objectives and goals and they can assess how close they are to them. Maybe at some states some of the objectives need to be changed or corrected, or some of them may be omitted from the list because they are hard to reach. Also it is very important that the review sessions are held in the presence of the managers of the hospital where these changes are going to be implemented. This helps because they are the ones that must be satisfied by the outputs and can decided whether goals must be removed or altered.

Measure

Strong knowledge about the activities that are performed in emergency departments has to be built in order to quantify the problem any base improvement efforts on a solid base. This knowledge has to have a sufficient management and staff support to produce the desirable output of this phase.

As a first step, common causes of patient waiting time in emergency departments has to be identified through observation and literature. We used literature to identify the major causes of patient waiting times in ED and the causes are shown in the fishbone diagram in figure. The causes identified has to be taken into consideration along with any other cause that is observed in the emergency department. As a result, the objective of this phase is to identify causes of patients' waiting times in ED and collect the required data. Causes that are unique to the emergency department that this study is going to be applied to will be identified using observation, interacting with patients, physicians, nurses, and other staff who work in the hospital.

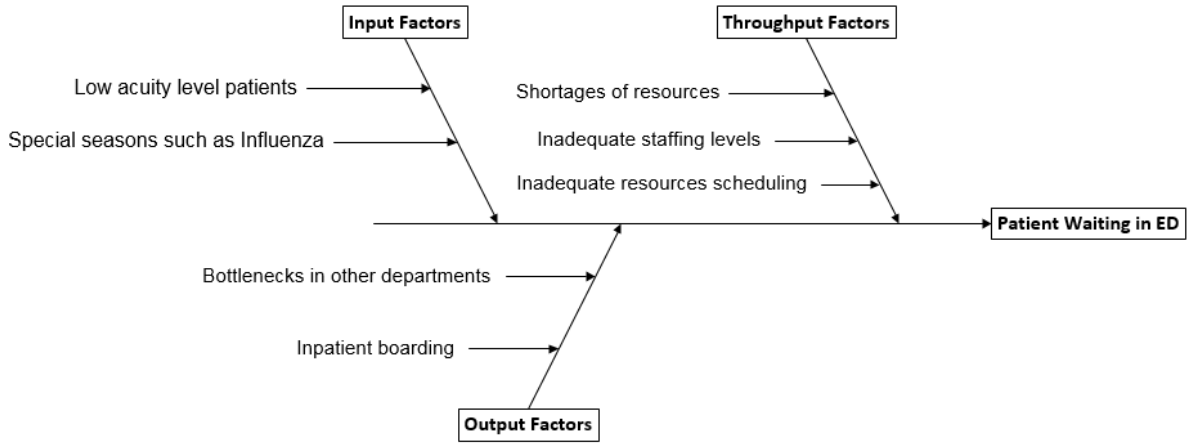


Figure1: Cause and effect diagram of patients waiting in ED

A discrete event simulation model will be built to assess the current service level of the ED, identify the bottlenecks, and account for the uncertainty of patients arrivals, patients' service times. This simulation model will be used to evaluate the effect of the proposed improvements. A process map of the ED will be constructed and the processes that are needed to build the simulation model will be identified. A data collection plan will be established and the data will be collected by a trained data collector/s. Measurement system has to be analyzed to make sure that the inputs we collect are accurate. For example, start and finish time of each process has to be clearly identified to all data collectors. If the hospital has an electronic data collection system, a validation process has to be done to ensure an accurate simulation input. In addition to the work done in the define phase to define CTQ, information related to customers will also be collected in this phase.

Analyze

This phase is essential as the majority of statistical analysis is performed in order to determine the significance of each cause of patients' waiting times in the ED. The simulation model will be finalized in this stage as data will be ready to be input into the model. This model will be used to identify the processes that form bottlenecks in the ED and to measure

the actual performance of the current system. Simulation is a valuable tool that will allow our team to test several what if scenarios and choose the optimum suggested improvement among the improvements that are going to be suggested in the improve phase of this study.

In order to identify the root causes of long patients' waiting times in the ED, the output of the measure phase and the baseline simulation model will be used as inputs to the analysis that is going to be performed in this phase. Tools such as Pareto chart, histograms, regression analysis, and hypothesis testing, 5 whys, correlation and scatter plots, and run charts will be utilized as necessary to determine and visualize the root causes and their effects. The cause and effect diagram that was constructed in the measure phase can be enhanced more in this stage by doing a more thorough study on the causes that were identified as root causes.

This stage will be utilized again after implementing the suggested improvements to test whether or not the suggested improvements will have a significant difference from the current system. A hypothesis testing will be performed on all suggested improvements as follows:

$$Ho: There\ is\ no\ significant\ difference\ between\ the\ suggested\ system\ and\ the\ current\ \ system$$

$$H1: There\ is\ a\ significant\ difference\ between\ the\ suggested\ system\ and\ the\ current\ \ system$$

Performance measures that determine the performance of the ED such as total patient waiting time in the ED, patients waiting time in queue in bottleneck processes and other processes, proportion of patients' no shows will be tested using the hypothesis testing mentioned above.

Improve

In improve section of the DMAIC, goal is to make necessary changes to the baseline model created and described in analyze and measure phases in order to find areas of improvement [1]. The improvement can happen after eliminating the defects that were found in the root cause analysis done in the previous phases. In this phase, goal is to make alterations within the baseline model described previously. As mentioned in analyze section, the collected data from the patient processing and waiting times in the ED must go through the simulation model in order to process the current state of the system. After analyzing the results obtained from the baseline model (performance measures such as average waiting time in the system and average number of patients in the queue are the most important ones), it must be studied that how changes in the model can result in reducing these numbers. Two of the possible approaches are discussed in the following paragraphs

First possible scenario for improvement would be to study the process map in order to find the possible bottlenecks in the system and eliminate those steps in the simulated model. When there are several possible alternatives that can be applied, the optimal approach would be to choose the design of experiments (DOE) approach to test the alternatives. In DOE, first step is to quantify the proposal to change as hypothesis tests with various conditions. As an example, if the proposed change is to adding nurses to a specific stage, such as triage, a study must be designed to collect the necessary data after adding the number of nurses and test if the average waiting time and the average number of patients in the queue have changed significantly.

Next possible idea that can be implemented for improvement if testing the hypothesis in design of experiments is not possible is to directly apply the recommended changes into the simulation model and get the final results. This is a completely valid approach since the ultimate goal of a simulation project is to first understanding the current state of the system and then make changes to the model in order to find the optimum solution for improvement. The changes can also be derived from shrewd study of the process maps. Some of the possible changes can be to add servers (such as nurses) or changing the capacity of servers, or to add sequencing rules to the queues in a way that can be led to increasing throughput, decreasing average waiting time and decreasing the average number of patients in queue. A good benefit of using simulation is that comparing to other methods such as DOE it is less costly and time consuming and also many alteration can be tested. Applying DOE, collecting corresponding data, and analyzing them can take a lot of time and may not result in significant improvement if the experiment has not been carefully designed. On the other hand, in simulation multiple different scenarios can be tested and many other performance measures can be extracted from it other than the ones that are under the study. Validation techniques can be applied to the results in order to check if the alternative model is working appropriate.

With these two scenarios, another alternative would be to use DOE and simulation at the same time. Although it can verify the solutions by double crossing the results but it can be very time consuming.

Another method that can be used in the improve measure of DMIAC framework is to perform a FMEA (Failure Mode and Effects Analysis) to give ranks to the identified failure modes discussed in the root cause analysis section. In FMEA, the goal is to combine the technical concepts with experience of the employees and managers in order to identify the foreseeable failure modes of a service [1]. The motivation for proposing to utilize FMEA is to use a qualitative tool in addition to the two quantitative tools (DOE and simulation) mentioned above. By using FMEA the project team can recognize and rank the possible failure modes, then propose necessary actions that can be helpful in eliminating the occurrence of failure, and finally document the whole process. Also by implementing FMEA and finding the possible failure modes, they can be ranked according to the measures such as the frequency of occurrence, risk factor, and detectability of the failure. Then in the next step the resources can be allocated to eliminate the root causes with the highest priority. This is the importance of introducing a qualitative method to support the quantitative tools.

Control

The final phase of DMIAC, control, consists of sections such as evaluating the performance of the improved system, standardizing the process that leads to an effective improvement, and drawing reliable conclusions based on those results. In general, the objective of the control phase is to monitor and evaluate the process after implementation of the improvement recommendations and study the effectiveness of those efforts through various types of data collection and monitoring. For the purpose of this project, the two major steps of evaluating the process and standardization of the procedure will be discussed in the following paragraphs. It is very important to mention that these two steps happen instantaneously after improving the system.

Objective of the evaluation stage is to monitor and assess the effectiveness of the implemented changes in the improve stage through data collection and the powerful tool of control charts. There are various type of control charts for both attributes and variables that can be used in this section of the project. Data that has been gathered from the baseline model and improved model can be transferred into a control chart to portray the improvement of the process. Data such as the number of patients that suffer from waiting time, number of patients in the queue through time, and average waiting time are the performance measures that can be collected and then by utilizing the control charts we can see the changes before and after the improvement. Control charts must be continuously updated through intervals of time to make for the purpose of tracking the improvement. At any point where the process is going out of control it must be investigated that if there is an assignable cause for that point. The evaluating stage can be considered as the quantitative or technical section of control phase

After evaluation, standardization of the improvement procedure must be done once the changes are shown to be satisfactory. This is to make sure that in future, any change that is going to be made in the system must follow a specific guideline. Various frameworks can be used to standardize the workflow and here, we propose to use the PDCA cycle for this purpose. Basically the objective is to design and establish a framework using PDCA in order to continuously check if the implemented improve solution are effective and satisfactory. PDCA is comprised of four steps of Plan, Do, Check, and Act. In this framework, in Plan we document the improvement solutions. In Act the hospital must implement those and record all the outcomes. In Check it must be studied whether the results are satisfactory or not and if required, necessary changes must be added or removed to the process maps. Finally in the Act the team must perform the required changed, document them, and again the whole cycle starts from the beginning. The huge advantage of using PDCA is that this is a cyclic process that continuously tracks the process and looks for the area of improvements. Therefore using PDCA for the standardization of the control phase of DMIAC can be of huge benefit.

Conclusion

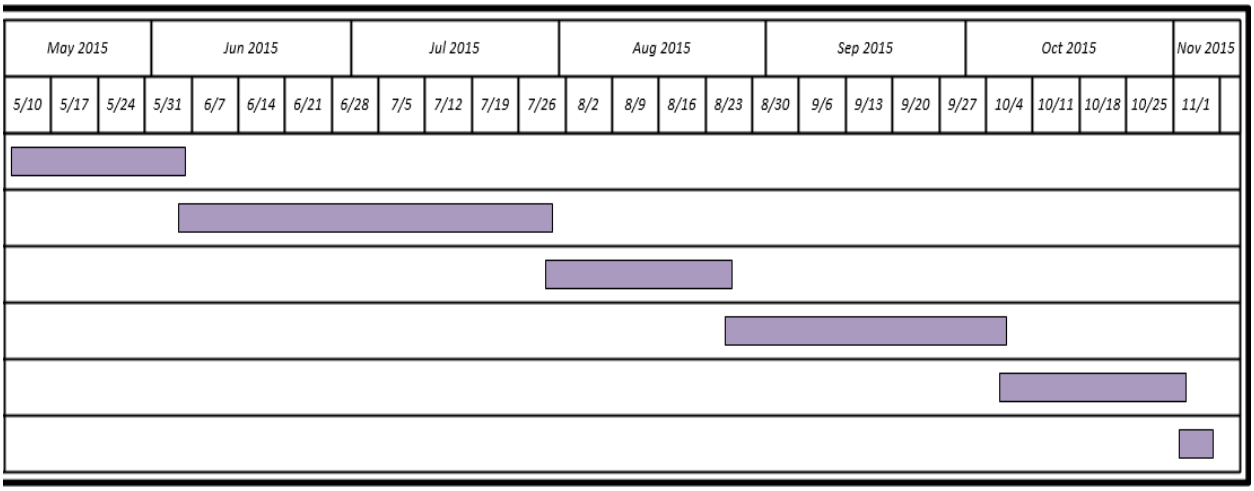
In conclusion, the purpose of this paper is to introduce and design a methodology that can be used to reduce the patient waiting time in emergency departments. The project team introduced the problems that can lead to the increasing waiting time in ED and proposed that by using Six Sigma DMAIC framework integrated with PDCA cycle, the patient waiting time can be reduced, if not completely eliminated. There are different methods and toolsets that can be implemented in every phase of the DMAIC framework. Among them, appropriate techniques have been selected for each phase. In define, a project charter containing objectives, scope, requirements and other specifications of the project have been used. In measure, by studying the literature different techniques for collecting necessary data for analysis of the system were used and a fishbone diagram of the possible causes of waiting time in emergency departments has been constructed. In Analyze phase, authors suggested a simulation approach to build a model of a general ED unit and analyze the current state of the system using the collected data in the measure phase. In improve, after establishing the current sigma level, team proposed areas of change and in order to test if these changes will lead to actual improvement, meaning reduction in waiting time, we have proposed an integrated approach of simulation and design of experiments to verify if they will actually lead to improvement. Using FMEA as a qualitative tool in this phase

was also suggested. Finally in the control phase of DMAIC, authors proposed to use real time control charts as the evaluation of the process and the PDCA framework for standardization of the whole improvement process so that it can be applied in other sections of a hospital. Using PDCA, continuous improvement is realized and improvement will be integrated in every step of each process within ED unit.

Timeline Study

Now that the methodology has been explained, a study of timeline will be provided in order to assess the estimated time necessary to finish this project. Our team has prepared a Gantt chart for this purpose that can be seen in the following table:

ID	*Task Name*	*Start*	*Finish*	*Duration*
1	Define	5/11/2015	6/5/2015	4w
2	Measure	6/5/2015	7/30/2015	8w
3	Analyze	7/30/2015	8/26/2015	4w
4	Improve	8/26/2015	10/6/2015	6w
5	Control	10/6/2015	11/2/2015	4w
6	Results Presentation and Documentation	11/2/2015	11/6/2015	1w



The estimated period that our project is going to take is approximately six months. Measure phase will take the greater portion of the time allocated for this improvement project as it involves causes identification, data collection, and building the simulation model. The start and finish dates are not rigid as some activities that belong to two different stages may be done simultaneously. Also, the output of some stages will be used to update previous stages. For example, the output of measure phase will be used to update KPIs in the define stage.

Why this project can be considered unique?

In this project, we proposed to integrate two methodologies of Six Sigma DMAIC and PDCA to propose ways to improve ED units by reducing patient waiting times. The use of PDCA was to help standardize the improvement process and to keep this process continuous. Every improvement project must be cyclic and continuous (since after every improvement new flaws will appear and therefore improvement may be required again), therefore use of PDCA after the outcomes of DMAIC framework can help evaluates and standardize the workflow. Another strategy that was used in on the DMACI phases was the utilization of a discrete event simulation and integration of it with design of experiments. It was mentioned that these two tools can be used together and alternatively. Project team aims to deliver following performance measures after implementation of this framework in a hospital setting:

- Reducing Patient Waiting time
- Increasing processing time
- Increasing patient satisfaction
- Standardization of the improvement procedure in order to be able to implement it in other units as well

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