

Lean Six Sigma: Process Improvement at Hospital X's Emergency Department

*Elis Nanay Torres Torres
Master of Engineering in Manufacturing Engineering
Advisor: Dr. Carlos González
Industrial Engineering Department
Polytechnic University of Puerto Rico*

Abstract — *The opportunity to establish and outcome some frequently used industrial and process engineering tools in a 28-bed, hospital emergency department (ED), located in Puerto Rico, was presented to CIRACET Corp. With the determination to become a more efficient, effective, and compliant to meets society and business needs, the hospital decided to use their emergency department as the focus of a Lean Six Sigma study. Prolonged waiting times at the emergency department reduce quality of care and increase elopements. Patients believe to be discharge in less than 4 hours. For Hospital X's emergency department, patient's length of stay (LOS) was approximately 4.92 hours. Multiple deficiencies in the emergency room (ER) such as process effectiveness, patient flow, human resources, etc., were found. The analysis shows that reducing walking distances, relocating human resources, and changing the workflow within the clinical processes will achieve a patient's length of stay lesser than 4 hours.*

Key Terms — *DMAIC Six Sigma, Healthcare Institutions, Lean Manufacturing, Patient's Length of Stay.*

LITERATURE REVIEW ON LEAN SIX SIGMA AT HEALTHCARE INSTITUTIONS

Every healthcare organization boarding on a process improvement program needs first answer some challenging questions: How and where start improvements? What tools should to be used to define, measure, analyze, improve, and then control the hard achieved improvements [1]? In a 2009 survey of U.S. hospitals, 53% reported that they have adopted Lean Six Sigma to some scope; of those hospitals, 60% reported that they have

adopted Lean Six Sigma in the emergency department. Additionally, some public healthcare systems, as well as the U.K. National Health Service, have implemented or are planning to implement Lean Six Sigma as a drive for decreasing costs and improving the quality and safety of care [2].

Lean Six Sigma means a measure of quality that strives for approaching perfection by eliminating defects and wastes in a system or process. Lean Manufacturing and Six Sigma are toolkits to decrease waste in business processes. Lean Manufacturing involves the philosophy of continually increasing the fraction of value added activities of their business through constant waste elimination. Meanwhile, the Six Sigma DMAIC methodology uses a five-phase approach to understand and solve problems, and they are summarized below [3]:

- **Define** a problem, set a goal leaded for customer satisfaction and business objectives.
- **Measure** the system or process by gathering important data to understand issues and for potential comparisons.
- **Analyze** to validate cause and effects of problems.
- **Improve** in order to reduce variation and wastes, based on the analysis.
- **Control** the system or process and keep the reduction of variation and wastes.

Emergency departments play a significant role in a patient's treatment cycle. The patient could be admitted to the hospital, transferred to another hospital, or discharged based on an emergency medical doctor (MD) plan [4]. Some patients that headed to an emergency department for a quick response to a medical issue have experienced long waiting times. Many hospitals find themselves in

the same situation as demand for services increases, while cost burdens pressure the accessible medical staffing for safe, high quality medical care [5]. This is why, for the past decade, a recurrent request from hospitals is the improvement of patient flow and capacity in the emergency department. Lean Six Sigma is the right method in analyzing patient flow, optimize the use of resources, and implement changes in the fast-paced emergency department environment.

HOSPITAL X'S EMERGENCY DEPARTMENT BACKGROUND

Emergency departments crowding has become an ever-present, international phenomenon. Departmental layout and staffing levels are examples of inherent factors that influence patient flow. The following project seeks to identify evidence-based strategies to reduce the amount of time patients spend in the emergency department in order to improve patient flow and decrease crowding in the ED.

Confidentiality Agreement

Due to confidentiality reasons, CIRACET Corp. is unable to publish the hospitals or health institutions' names and the full content of some of the reports we receive from our projects. This is to ensure the privacy and security of patient health information as a top priority for patients and their families, health care specialists and professionals, and the Government due to HIPAA privacy law.

CIRACET's Background

CIRACET Corp., located in Ponce, Puerto Rico, provides a myriad of solutions for the effective management of healthcare technology while assisting providers with diverse consulting and service options. A talented group of engineers and healthcare professionals allow the company to support healthcare technology adoption while providing process improvement guidelines, education and technical support expertise.

Hospital X's Emergency Department Introduction

The emergency department at Hospital X is composed of various areas divided as follows: Fast Track area and Observation area. There are two doctors in the Fast Track area during the first and second shift (7:00 AM to 3:00 PM and 3:00 PM to 11:00 PM) and one doctor during the third shift (11:00 PM to 7:00 AM). In the Observation area, one doctor is available in every shift. Also, the nursing staff available during all shifts for Fast Track goes from 2 to 4. At the Observation area are 7 nurses (RN). It is also important to notice that 80% of the ED visits go through the Fast Track Service, and that the 70% of the hospital admissions are originated from the ED.

In 2016 there was an average of 2,676 visits to ED. Meanwhile, in 2017 the average has been 3,105 visits. This project drove the hospital to maintain this increase while maintaining service at an optimal level. The project followed to impact patient's length of stay and time from arrival to medical doctor at ED. The hospital's metrics presented that Hospital X's LOS was 4.92 hours, which it is supposed to be at 4 hours or less to meet patients' satisfaction. This information was validated using Engineering Management tools learned during the master degree.

Thesis Statement

Hospital X has experienced a 15% increase in ED visits during 2017. Most of the ED visits are not emergencies; however, patients expect to be seen by a doctor and receive a treatment within less than an hour of their arrival and to be discharge in less than 4 hours. In this case, there is an increase in ED elopements and unsatisfactory waiting times. These difficulties result from multiple deficiencies in the emergency room such as process effectiveness, patient flow, human resources, etc.

Project Objectives

The main objective of this project is the improvement of the clinical process in ED by:

- Reducing patient LOS during an ER visit by 25% or to 4 hours on average (current LOS is 4.92 hours on average).
- Reducing the patient’s waiting time to see the medical doctor (MD) by 25% or up to 30 minutes on average.
- Increasing process sigma (minimizes variation) from 1σ (actual) to 3σ (required).
- Increasing value-added activities from clinical processes to 25% reducing wasted tasks.
- Providing new tools and alternative ways for ED personnel to perform their different tasks in order to become more efficient and effective.

ANALYSIS

Through data collection and analysis, it was found that the average cycle time for treat and release, walk-in ED patients was more than 4 hours. As a result of the project, improvements were made to ED process that not only decreased cycle times, but also raised patient satisfaction. Once the appropriate changes were made to the process, staff members were not only seeing more patients, but enjoying their work more.

Phase I: Define

In the first phase, Define, a value stream map (VSM) was created to have a high level view of the process and understand the desires of the customers of the process. It analyzes the actual state of the process by the following terms, the creation of flow (value added), and the elimination waste (non-value added).

The VSM presented below in Figure 1 illustrates the current state of the ED clinical processes at Hospital X. Basic processes could be identified each one represented by a square, arrows represent a patient being pushed into the next process, and a triangle represent a patient not being serviced or waiting for the next process to start.

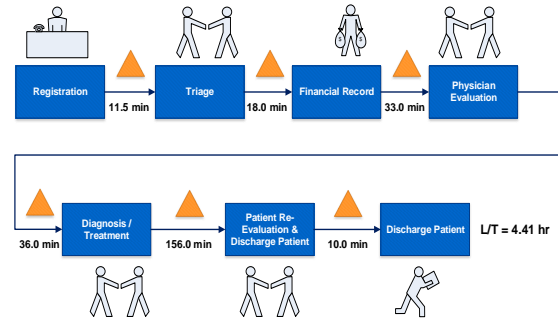


Figure 1
ED Clinical Processes at Hospital X Current State Value Stream Map (Lead Time = 4.41 hr.)

Phase II: Measure

“You can’t manage what you can’t measure”. The most important phase for the success of a Six Sigma project is to focus on continuously measuring the process yield. It is necessary to measure service times, delays and waiting times, patient length of stay, variability among shifts, days, months and years. Most of the data captured was obtained by a Hospital information system and from the medical records. Meanwhile, other data was gathered performing a time study analysis.

The current state Value Stream Map in the below figure was used for the time study analysis. Each ED process were measured; the observer recorded the actual time taken to do the element or operation, using a stop-watch. As it can be seen, the initial treatment process, which is performed by the nurse, is the constraint or the longest process (cycle time).

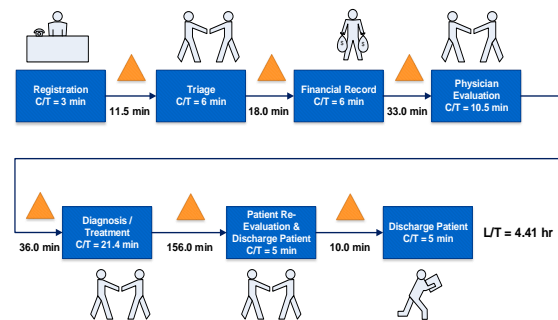


Figure 2
ED Clinical Processes at Hospital X Current State Value Stream Map (Longest Cycle Time = 21.40 min.)

Phase III: Analyze

The objective of Analyze is to obtain the root causes and possible improvements of the problems in the studied process. This phase statistically reviews the families of variation to determine significant contributors to the output. The families of variation and their contributions are quantified and relationships between variables are shown graphically and numerically to provide the direction for improvements.

At the emergency room, patients are seen based on their emergency or urgency. At the Triage, patients are initially assessed and divided in one of two categories: Emergency and No Emergency, but also this categorization is evaluated by priorities as it can be seen in the following figure.

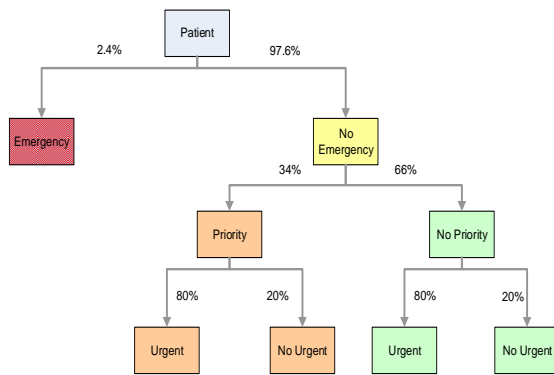


Figure 3
Patient Classification at Triage

It is vital in Lean Manufacturing that to fix any problem first identify the waste. In this case, it was observed several deficiencies in ED such as process effectiveness, patient flow, human resources, and so on. The process cycle efficiency (PCE), the ratio of value added activities (service times) within the process, was calculated using equation (1):

$$PCE = \frac{\sum \text{Value Added Activities}}{\text{Lead Time}} \quad (1)$$

For the ED process, the PCE is approximately 22%. Based on Lean standards the PCE should be 25% or more. In order to increase the PCE in ED, waiting times should be decreased.

The graphs below present the impact patient's LOS and time from arrival to medical doctor (MD) at ED. Hospital X's LOS was 4.92 hours on average and the time from arrival to MD is on average 1.24 hours.

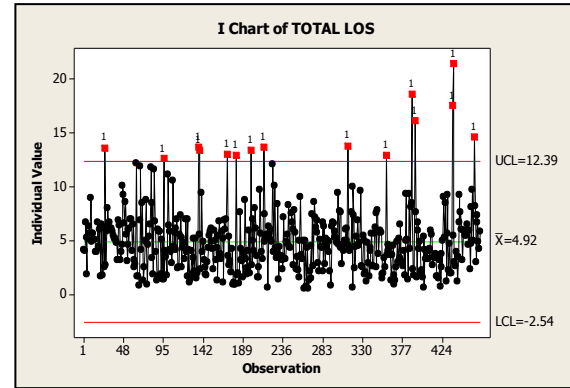


Figure 4
Time from Arrival to Patient Discharge

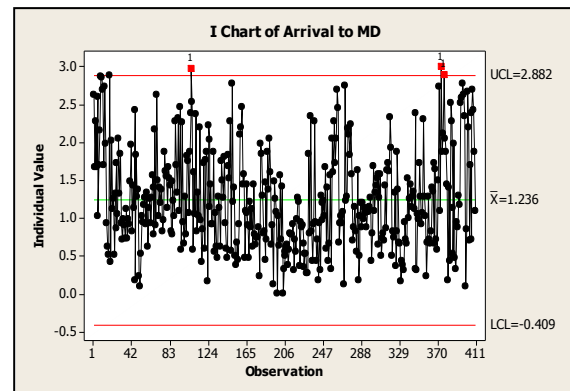


Figure 5
Individual Control Chart for Time from Arrival to Medical Evaluation

On the other hand, the Process Capability Analysis is an evaluation of the process variability and capacity to meet customers or business specifications. This analysis is based on the specification limits that are desired as an objective. The specification limits for the time from arrival to MD evaluation were set to 0.0 hours for the lower specification limit and 0.5 hours as the upper specification limit. The specification limits for the LOS were set as 0.5 hours for the lower specification limit and 3 hours as the upper specification limit. In both cases, the data was transformed since data was not normally distributed.

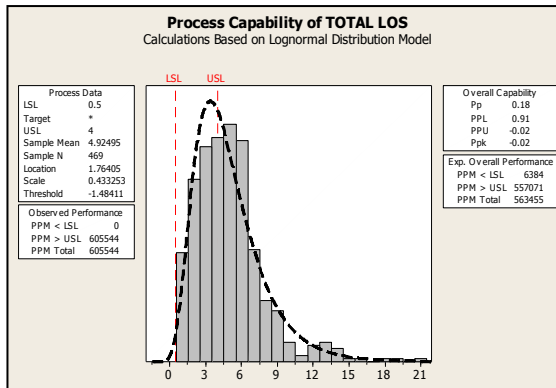


Figure 6
Process Capability Analysis

Sometimes is convenient to express or measure process capability in a simple quantitative way. The process capability ratio, p , is a measure of the ability of the process to meet business or customer specifications (e.g. for the arrival to MD time the specifications are 0 hours to 0.5 hours) and it is used the following equation:

$$p = \frac{USL - LSL}{6\sigma} \quad (2)$$

At Hospital X's emergency department, the capability ratio ($p = 0.18$) is much lower than what it is expected for an existing process ($p = 1.33$), which means that the process is not capable of handling these specification limits. The higher the capability ratio the more capable is the process meeting specifications.

Meanwhile, process sigma is the capability of the process comparative to customer specifications; is an expression of process yield or area under the normal curve using the specification limits. In this case, the actual process sigma is equal to 1. The average service process sigma should be 3σ . The process sigma should improve with a reduction in time and waiting times.

Phase IV: Improve

The goal of the Improve phase is to identify a solution to the problem by brainstorming potential solutions, selecting solutions to test, and evaluating the results of the achievements. This phase helps determine the relationships of key variables and lead to improvement ideas. Solid education and

analysis has identified these areas of opportunity in earlier phases.

Queues (people waiting on line for a service) at ED are prioritized based on patient's sickness level. Therefore, patients with low priority have to wait long. A queuing analysis will provide information on how long would a patient wait, the number of patients in the system, human resource utilization, etc. A queuing analysis was performed for the actual process flow and various alternatives were presented as recommendations. Table 1 presents the service and arrival rates used in the following analyses. More resources will be needed whenever the arrival rate is higher than the service rate. Resources could also be calculated as standard time production rate and it will yield the same result.

Table 1
Capacity Analysis

Server / Resources	Patient's Arrival Rate (pt./hr.)	Service Rate (pt./hr.)	Resources Needed*
Triage RN	4.0	10.00	0.40 ≈ 1
Financial Registration	4.0	10.00	0.40 ≈ 1
Fast Track MD	6.0	5.71	1.05 ≈ 2
Fast Track RN	3.2	2.04	1.57 ≈ 2
Observation MD	0.8	2.00	0.40 ≈ 1
Observation RN	1.6	1.50	1.06 ≈ 2

*Resources needed were calculated dividing the arrival rate with the service rate.

On the other hand, table 2 highlights sources of waste and the consequences of eliminating them by possibly implementing some recommendations.

Table 2
Conclusions and Recommendations

Conclusions	Recommendations
Reduce walking distances will provide a continuous clinical observation.	A new layout for the Fast Track Area.
Change the workflow	The patient should be in the system after Triage. Actually, the patient goes to the waiting area after each process.

Medical records are not properly classified after medical evaluation. No one knows which patients are receiving treatment, waiting for a treatment, or waiting for reevaluation.	Medical records should be classified to keep track of the status of a patient efficiently.
Search for opportunity areas to improve the operation of the system and its interaction with the user.	MD must put the orders in the system. RN must make the discharge in system, at the moment that gives instructions of discharge to the patient.
Laboratory tests are delayed because nurse has to walk long distance to the Laboratory to hand in the blood samples.	A pneumatic system could be the best solution to avoid long walks and delays in sending blood samples to the Laboratory.
Processes at ED are classified as a PUSH system instead of a PULL system. Nurses are the ones that push or send the patient to the Evaluation Areas even if the doctor is not available.	It should be the doctor the one that calls the patient once Triage and Financial Registration are completed.
Coordination of services of admissions and emergency room.	If there are not available beds, patient must go directly to Observation since the process of ER by Fast Track is not needed.
Nurses make many tasks that are not patient care oriented as phone calls for consults, laboratory documentation, etc.	A ward clerk is recommended

Phase V: Control

The main goal of Control phase is to permanently implement all the necessary improvements in order to reach the objectives of the project. It is important to guarantee that the advances obtained during Improve are maintained long after the project has finished. It is needed to standardize and document processes, educate all employees, and reveal the project's results. In addition, the project team needs to create a plan for ongoing monitoring of the process and for reacting to any problems that arise.

As improvement is not a separate activity and must be built into the work process, a plan-do-

check-act (PDCA) cycle, known also as the Shewhart cycle, was developed with the intention to repeat it again and again for a continuous improvement effort, and it is shown in Figure 7.

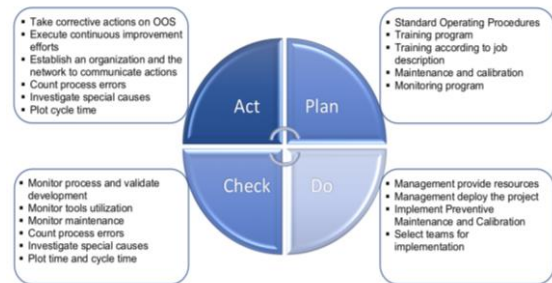


Figure 7
PDCA for ED Processes

The implemented monitoring program took into consideration who is responsible for collecting data on every shift, who is the trained resource to load the data and where was the best place to post the results for group discussion. This phase will be completed by Hospital X's.

CONSTRAINTS

During this project, Hospital X was unable to share with CIRACET Corp. the full content of some of the medical reports due to confidentiality reasons. Some of this information possibly was valuable for statistics purposes.

CONCLUSIONS

This project revealed that deficiencies in the emergency department such as process efficiency, patient flow, and human resources have a significant effect in the patient's length of stay and the arrival time to the medical doctor. Changes are not yet fully implemented, but is expected that the recommendations and findings made on this paper improve ED's process efficiency and, consequently, reduce patient's waiting times. Post-implementation analyses will be done in order to assure the success of the process improvement.

Supporting the changes made will assure lasting results. The best controls are those that involve no monitoring, but oftentimes there are

process settings, setup procedures, and so on, that require workforce to keep an eye on specific requirements in daily operations. In cases like this, CIRACET Corp. should do the whole thing possible to mistake-proof (poka-yoke) the process and add the appropriate checks and balances to the quality system for the long run.

ACKNOWLEDGMENTS

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