

Lean Six Sigma Application to reduce cycle time in the waiting process for medical attention in patient with green categorization in adult emergency area in Hospital X

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Abstract-The service area is one of the healthcare industries area that are in continuous search to optimize their process in order to provide a quality service to their customer (patient). In order to provide a total to quality service and reduce variable and eliminate waste in their process, many healthcare industries adopt the implementation of Lean Six Sigma methodology in their process. The Lean Six Sigma methodology is a useful tool based on maximizing value and minimizing waste. The design project focus in the implementation of lean six sigma tools from the Triage until medical treatment in the adult emergency department in order to reduce the variables and waste that make the waiting time process to be medical treated extended. This implementation aims to reduce the waiting cycle time in a 25% at the same time it seeks to eliminate the patient drains from the waiting area.

Key Terms– Healthcare, Lean Six Sigma, Emergency Department

categorization. Approximately a 55%-60% of patient that enter to the emergency room daily are categorized green. The drain percentage is approximately of 4% and represents \$20,706 of lost monthly in the adult emergency room.

Table 1
Triage Categorization

Color	Priority	Definition
Red	1	Critically ill patients, potentially recoverable, which requires immediate medical attention.
Yellow	2	Critically ill patient that require immediate medical attention.
Green	3	Patients with minor injuries, which can put off your care without putting your health at risk.
Black	4	Patient with fatal injury or deceased at a moment to arrive the emergency room.

PROBLEM OVERVIEW

The adult emergency room receives approximately 151 patients daily. The area has a capacity of 21 beds and 8 seats. Is a requisite that each patient those enter to the emergency room need to pass for a process called Triage where the patient is evaluated by a nurse and categorize (see Table 1) according to their symptoms.

After patient were categorized pass to a series of process and waiting that make the medical treatment process extensive. The patients through this process wait approximately 7 to 8 hour to be treated. This situation cause one of the major problems in the area that is the patient drain. These drains of patient occur entirely in patient with green

RESEARCH DESCRIPTION AND OBJECTIVES

The design project is a study that had been proposed to analyze the possibility to optimize the waiting time process to be medical treated in the adult emergency room using the Lean Six Sigma methodology and tools. Also the project aims to reduce the cycle time and costs of the process from Triage until receive medical treatment in an approximately 25%. Otherwise reduce the drain of green categorization patient in the adult emergency room in approximately 50%.

RESEARCH CONTRIBUTION

- Reduce patient drain in a 50%, principally patient with green categorization.
- Cost reduction in the emergency adult area and related areas.
- Re work and human error reduction.
- Documentation process improvement.
- Reduce cycle time of the process from the Triage to medical treatment in patient with other categorization in the adult emergency area.
- Increase work flow.
- Implement total to quality philosophy in the adult emergency area.

LIMITATION STUDY

For limitation of time the proposed improvements cannot be implemented during the development of the design project due this implementation need to be approved by the hospital management. In order to teach the personnel and have possible results of improvement implementations a Kaizen exercise will be performed with the supervisor of the areas and logistic personnel.

METHODOLOGY-DMAIC

DMAIC tool is divided in five phases. Define, Measure, Analyze, Improve, and Control (see Figure 1). Each one contains a package concept, tools, and statistical analysis. This project present each part of the DMAIC tools with a purpose to gathering all the information that will help to identify the area that will offer the major benefit and impact

Define Phase – Define the project purpose and scope obtaining background on the process and customer. An evaluation of the process must be visualized, this evaluation help to identify the sources that contributes in greater percent to the area of interest. That in this case is the area that needs to be optimized. After the completion of this

section a development of several tools and concept help me better to identify the areas to implement the propose improvement.

Some of the tools used in this phase are the following:

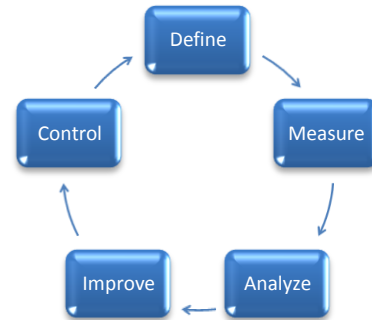


Figure 1
DMAIC Diagram

- Financial justification- demonstrates the financial impact of implement the design project. Based on the data obtained the implementation of the lean six sigma tools give a revenue in the area of approximately \$10,234 monthly.
- Project Charter- schedule of how to work to implement the project efficiently with the time proposed for the project.
- SIPOC Analysis- “identifies all relevant elements of a process improvement project before work begins” [1]. It helps us define the complexity of the projects and subdivided parts of the process (see Figure 2).

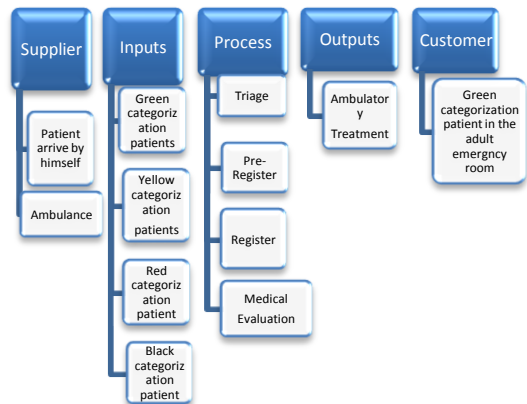


Figure 2
SIPOC Diagram

- Value Stream Map - Help to describe and identify the actions that add value to the process through the customer. With this information could be transformation needed through assessment the current situation. The final results are: have visibility for the interaction among customer process, suppliers and future recommendations. A value stream map for the actual process was development to clearly see how work the process actually to establish a baseline. With this baseline we can identify the deficiency in the process and determine what part of the process add value and what other part not add value. Also we can determine the bottleneck of the process in order to establish priority in the area of improvement implementation.
 - Voice of Customer- “capture the requirements/feedback from the customer (internal or external) the best product quality”. [2] This process is all about being proactive and constantly innovative to capture the changing requirements of the customers through time.
- Measure Phase - gather information of the current situation to be able to precisely define what problems are occurring and under what conditions they are likely to appear.
- A systematic approach was used for the measurements phase looking to clearly establish techniques for collecting data:
 - A measurement system.
 - Baseline data collection
 - Graphical display’.
 - Current situation overview by data tabulation.
 - The data collection in this case was observing the entire process step and taking the time of each process and the waiting time between each process.

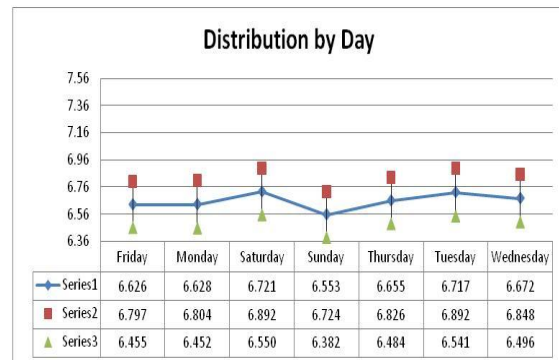
ANOVA- analysis performed to determine statistically which variable affect the process. Three ANOVA analyses were performed. The first two are a one way ANOVA analysis using a single

factor like the days of the week and the three shifts in the area. The third analysis is a two way ANOVA where the analysis use a combination of the two single factors. These analyses were performed to determine if the singles factors or a combination of both affect the process in the adult emergency room.

Table 2
ANOVA-Distribution by Day

ANOVA Table					
Source	SS	DF	MS	F	P-value
Between	0.768145	6	0.128024	0.446391	0.8472
Within	72.560	253	0.286798		
Total	73.328	259			
Pooled Standard					
Deviation =	0.535536		R-Sq =	1.05%	
DF =	253		R-Sq adj.	=	0.00%

Figure 3
Distribution by Day



In base to the result obtained in Distribution by days analysis (Table 2 and Figure 3), a P value of 0.8471 concludes that the null hypothesis (H_0) is accepted. Not exist evidence statistically significant to conclude that the days are a factor that affects the process in the adult emergency room. The process during the seven days of the weeks remains constant

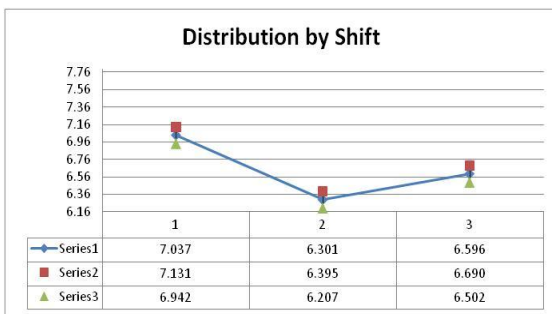
The P value of 0.0000 obtained in Distribution by shifts analysis (Table 3) means that have evidence statistically significant to tell that the shift is the factor that affect the process. Due this P value of less than 0.05 the null hypothesis was rejected. The table (Figure 4) presented show a clearly

difference between shifts be the first shift the worst case with approximately seven hours in bring medical treatment to green categorization patient in the adult emergency area.

Table 3
ANOVA –Distribution by Shift

ANOVA Table						
Source	SS	DF	MS	F	p-value	
Between	23.033	2	11.516	59.920	0.0000	
Within	47.858	249	0.192199			
Total	70.890	251				
Pooled Standard Deviation = 0.438405						
R-Sq = 32.49%						
DF = 249						
R-Sq adj. = 31.95%						

Figure 4
Distribution by Shift



Although the three shifts were performed the same process during the first shift the process is longer. This may be due to the flow of patient and that most green categorization patient entering during this shift.

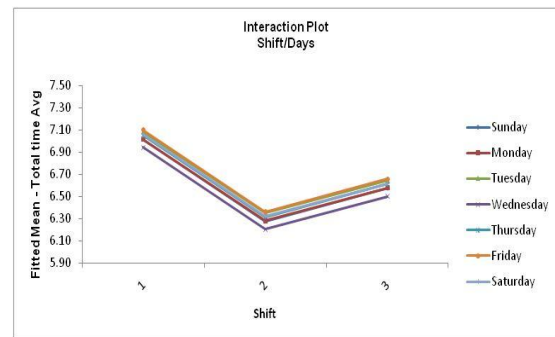
The two way ANOVA analysis is an interaction between the days and the shift. To confirm the result that the factor that affects the process is the shift (see Table 4). The analysis show a P value of the days in 0.6705 versus a P value of 0.0000 for the shifts. Conclude that the shift is the variable to affect the process due the flow of patient and the amount of green categorization patient that arrive to the emergency room change by shifts. The graph (see Table 5) clearly shows that the first shift is the worst case with a delay of total time about seven hour to attend

a patient in comparison of the second and third shift the present a total time about six and a half hour

Table 4
ANOVA- Days vs. Shifts

Source	DF	SS	MS	P
Shift	2	1.919	0.959706	0.0000
Day	6	0.050238692	0.008373115	0.6705
Error	12	0.148155	0.012346261	
Total	20	2.118	0.105890262	

Figure 5
Distribution Day vs. Shift



Analyze Phase- “transform the data obtained in the measure phase into information through the reviewing of reports and data analysis” [3]. This section addresses the analysis of data for the purpose of identify the possible reasons behind the process failures. The information obtained from this analysis can provide approaching into the sources of variability and unsatisfactory performance, and help to improve the process.

The tools used in this section were used to transform the data collected in the last section on information to help us determine what or which factors are affecting the process to well implement improvements in the areas.

- Future Value Stream map- Once identified the waste in the value stream map we demonstrate the way to eliminate them in the implementation of a Future Value Stream Map (see Table 5). The goal in this part is generate a continuous flow as possible to producing with the customer requirements. The

future value stream map explains the different improvement that helps to achieve the goal of reducing the waiting time.

Table 5
Future value stream map improvement

Current value stream map		
Lead time (min)	Value added time (min)	PCE (%)
484 min	203 min	42%
Future value stream map (without fast track improvement)		
Lead time (min)	Value added time (min)	PCE (%)
430 min	203 min	47%
Future value stream map (with fast track improvement)		
Lead time (min)	Value added time (min)	PCE (%)
343 min	203 min	59%

- Cause and Effect Diagram- also known as (Fish Bone diagram) is a “Lean tool used to clearly identify the factors that affect the process. This is done by identifying the problem on the right side of the diagram and the causes in the left side”. [3] For this problem potential causes that were identified are:

- Procedure
- Equipment
- Facilities
- Manpower

- Affinity Diagram- organizes the generated ideas, opinions and issues into grouping based on the process relationship. These ideas were obtained after talk with supervisor and nurse of what are the factors to delay the process in the different areas. These ideas were organized in a diagram presented in Figure 6.

Improve phase- this phase emphasize on the development, try out, and implementation of solutions that addresses the root causes previously identified in the analyze phase. The following tools were used to development this phase:

- Potential solutions- Helps us to identify with the information obtained in the last phases what are the potential causes that delay the waiting attendance process in adult green categorization patient in the emergency room (see Figure 6). With the information obtained

we can determine that the not standardized procedure, the area localization and the personnel culture are the most potential causes of the delay. Based on this were developed possible solutions to fix it.

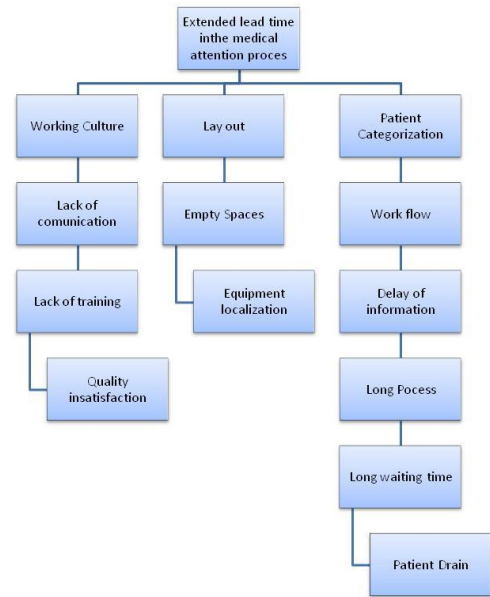


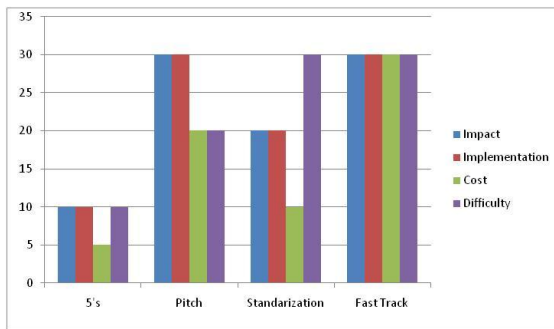
Figure 6
Affinity Diagram

- Prioritization matrix- identifies the best option to solve the problem (see Table 6). The criteria selected to evaluate the alternatives are:
 - The improvement impact in the process.
 - The time required to implement the improvement.
 - The cost involved in the implementation.
 - The difficulty to implement the improvement.

Table 6
Prioritization Matrix

Solution	Weigh	Factor								Total	Range
		Process Impact		Implementation Time		Cost of implement		Difficulty to implement			
		Rt	Sc	Rt	Sc	Rt	Sc	Rt	Sc		
5's	5	2	10	2	10	1	5	2	10	30	4
Pitch	10	3	30	3	30	2	20	2	20	80	2
Standardization	10	2	20	2	20	1	10	3	30	70	3
Fast Track	10	3	30	3	30	3	30	3	30	120	1

Figure 7
Prioritization improvement



Based on the prioritization matrix the following improvements are recommended to reduce the green categorization waiting time in the emergency department (see Figure 7):

- Standardization
- 5'Pitch
- Fast Track
- Kaizen
- Pilot test (Fast track implementation) - This pilot test was performed to demonstrate and confirm the recommendation. Only was presented the pilot test that is too long to implement but is the most impact improve in the area. The Pilot test performed is the fast track area (see Figure 8). The implementation consist in enable an area of the emergency room where all patient categorized green that have a condition that can be treated faster go to this area to receive medical treatment with the purpose to make the patient flow more faster in order to reduce the waiting time and patient drain.
- Implementation plan- reduce the waiting time in green categorization patient in the adult emergency room is presented in the following table. The implementation plan is divided per improvement and the time to take implement in the selected areas. This plan includes the assessment, development and monitoring of the activities or improvements.

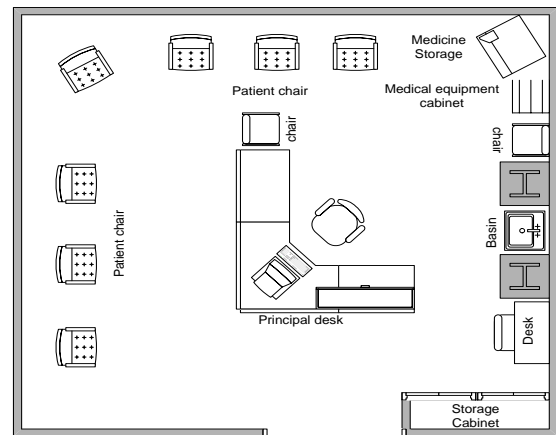


Figure 8
Fast Track lay out

Control phase- explain the finding and proposed recommendation based on the data obtained for the development of this design project and results obtained from the data.

- Before and after analysis- present the lead time and economic status at present and a future projection with the application of future improvements.

If the implementation plan proposed in the improve phase is performed. The emergency room can reduce the process lead time for about 6hour instead 8 hour and reduce the patient waiting time to about 1 hour instead 3 hour.

With the improvement implementation principally the fast track is expected to reduce a 50% of patient drain with revenue of approximately \$12,144 monthly.

If the area decide to implement the proposed improvement by area and reduce the process lead time to 6 hour instead 8 hour these improvements will impact the following:

- Increased employee deployment
- Reduction of patient drain
- Increase in yield.
- Reduced customer waiting time which means increased production.
- Monitor, control, and sustain plan- develop an organizational process to monitor, control and

sustain plan. These help to achieve the goals using time and resources.

To create a Sustainable Monitoring plan we develop them in the following five steps:

- Monitor project against schedule
- Monitor the project cost and expected effort
- Monitor the attributes of the work products and tasks
- Monitor resource provided and used
- Monitor the knowledge's and skills of project personnel.

Each monitoring help to compare the existing plan against the prepared plan with periodically reviews, identification of the results against expected, documentation, and communication of this monitoring.

Control plan is one of the most used tools to follow a logical sequence (almost always follows the flow of the process or operations) inspections. developed by a team where the staff must participate in the departments of supervisor, nurse supervisor, doctor and management.

To achieve optimum results in certain controls are necessary to follow the following steps:

- Conduct Progress review
- Conduct Milestone reviews

To verify that the controls have been correctly, analysis must be realized to monitor if the indicating parameters of the processes and products reflect their real state.

To sustain the plan, we focus on the stakeholders to assure that they understand and support the recommended improvements. To achieve the support we describe the tasks in each phase for the project stakeholders and other require support.

- Define: The Stakeholder planning and management continue during the Define phase as voices of the customer (VOC) assessments unfold. The list of stakeholders may grow or be adjusted as the processes and dependencies are better defined and understood. The charter will begin to take shape, and risk evaluation and

impact analysis will continue to bring rise to stakeholder and adoption challenges and opportunities.

- Measure: During the Measure phase, the detailed work begins. Defining the target environment and assessing the current environment to identify gaps will undoubtedly bring about numerous stakeholder issues, ranging from levels of performance or results in the current environment to readiness for the target environment.
- Analyze: During the Analyze phase the communication plans and stakeholder management plans should address the needs of broad stakeholder groups, while detailed employee transition plans address the needs of the people directly impacted by the changes.
- Improve: The Improve phase is the building stage. This is when processes and technology are built, tested, and validated. At this time change is translated to work functions, jobs, performance requirements, and staff plans, and training is built, tested and validated. This is where implementation plans receive final tweaks and controls are established, and stakeholder readiness is truly tested and validated.
- Control: During Control phase stakeholders are migrated to the target environment, and training and communications are completed. The change is implemented and controls validated. New requirements are reflected in performance scorecards, metrics and dashboards. Process changes are transitioned to business or process owners. The target environment is considered business as usual and the project or program is closed out.

CONCLUSION AND RECOMMENDATION

The design project was performed in the adult emergency room with the purpose to reduce the waiting time to be attended in green categorization patient and the same time reduces the patient drain. During the project development the goal was to

implement the lean six sigma methodology in the area in order to achieve the project objectives. This methodology normally is used in the manufacturing area but the continuous search to bring a quality service and improve the process move this methodology to the service area and this project demonstrate it.

The implementation of the lean six sigma tools through the four phases achieve the objective to reduce the waiting time process in green categorization patient at the same time reduce the patient drain and increase the process cycle efficiency in 5%. These improvements also serve as stimulus to implement this methodology in other areas.

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