

Application of the Lean - Six Sigma Tool to Improve the Time of Attention in the Emergency Department of a Hospital in the Department of Cauca

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Abstract: The use of lean methodology tools in the health sector leads to important operational and organizational improvements in healthcare institutions. This article presents the development of a proposal to improve patient care times in an emergency unit of a case study in the Department of Cauca. The problem presented refers to the non-compliance or excess of time that patients must wait to receive medical attention, detecting that the main causes of dissatisfaction are difficulty in accessing services, errors in care, and lack of medical and nursing personnel. The study begins by establishing the current state of the care processes in the emergency area, followed by the identification of the causes that generate delays and dissatisfaction on the part of the patients, and finally, a proposal for improvement is made. The results obtained show that the processes to be improved are from the moment the patient is admitted until he/she is attended to by the physician. It was also found that the spaces are poorly distributed and this also affects the proper care to be provided by the hospital.

Keywords: Emergency unit, Waiting times, Lean Manufacturing.

1. Introduction

The Lean methodology, which translates as lean production or without waste, was developed by Toyota Motor Corporation. It is a management model with good results in the industry, even in times of crisis [1]. Lean results in more satisfied customers, higher productivity, reduction in time and costs, and lower error rate [2].

The principles of lean thinking were originally born in the industrial sector, but have been applied in many areas, including healthcare [3]. This is because the organization's production processes are similar in that they focus on creating value for customers through process improvements [4], according to established schedules and timelines [5].

Lean methodology adapted to the healthcare sector has been described as a rational and scientific approach to problem-solving and learning, a familiar framework and aligned with a scientifically trained healthcare workforce [6].

The use of Lean tool is increasingly used in the healthcare sector and specifically in the care times in hospital emergency departments (ED). Several studies have shown that patient care tends to improve after its application, the duration of care decreases, as do waiting times and the

proportion of patients who leave the ED without being seen [1].

The fundamental right to health is autonomous and inalienable, both individually and collectively. Comprising access to health services in a timely, effective, and quality manner for the preservation, improvement, and promotion of health. [7]. International studies have determined that there is a wide variety of medical, social, financial, and external causes for overcrowding, and there is also a tactical recognition that the internal organization of emergency departments is often a source of inefficiency [8]. Colombia is no stranger to such problems, as established by [9] health in Colombia is negatively evaluated due to several situations, among which some deserve a few brief comments: (a) widespread corruption; (b) biological, social, economic and political injustice and inequity, which has generated the highest poverty rates in the country, such as those currently present; (c) considering the provision of health services as a speculative business, which should generate a lot of income and profits, and (d) the curative and not preventive mentality of businessmen, leaders, managers, and health professionals. This study is part of a research based on a case study, carried out in the emergency unit of a hospital in the department of Cauca, which seeks to improve the time of attention in the service through the application of Lean tools.

2. Methods

The study was carried out in the emergency department in three main stages, which refer to the establishment of the current state of the processes of care for patients

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admitted to the emergency department, the identification of the factors that cause delays in patient care, and the proposal for improvement of the patient care process. Each of these is developed below.

A. Current status of patient care processes in the Emergency Unit:

The entity taken as a case study is structured by 4 processes called strategic direction, provision of missionary services, management support, and control and evaluations.

The emergency service starts from the moment the patient enters the unit and ends when the patient is directed to hospitalization or discharged, the first stage is the reception of the patient where he/she registers his/her admission to the entity, at this stage the patient is assigned a shift of attention, the second stage is where the patient is called for medical attention established by the triage, The second stage is where the patient is called for medical attention established by the triage, the physician will assess the patient's condition giving rise to the level of priority concerning the others, it is here where the physician determines the procedure to follow such as observation, taking tests, hospitalization or in some cases medical recommendation and discharge, however, patients who are admitted by ambulance or those classified as Triage I are not included, since their condition requires immediate attention.

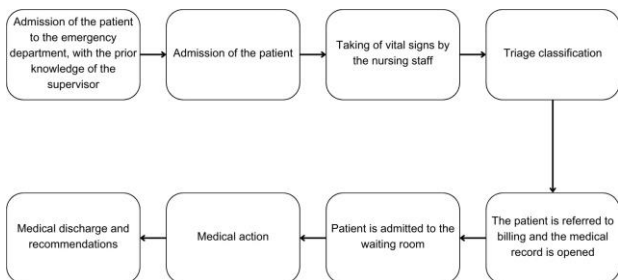


Fig 1: Current block diagram of the patient care process in the emergency area

An interview was conducted with the head nurse of the unit, to establish the care process for patients arriving daily to the service. Figure 1. Patients must follow eight steps to be cared for in the unit, from admission to discharge.

From the information collected, it is possible to identify that the emergency area has only two physicians for daytime care and one physician for nighttime care, three nurses during the day, and two at night. The nurses are responsible for the processes of billing, taking vital signs, registration, hospitalization care, application of medications, delivery of formulas, care in the observation room, attention to requests from the physician, and opening and closing of medical records. The following is the flow chart of patients arriving at the emergency department.

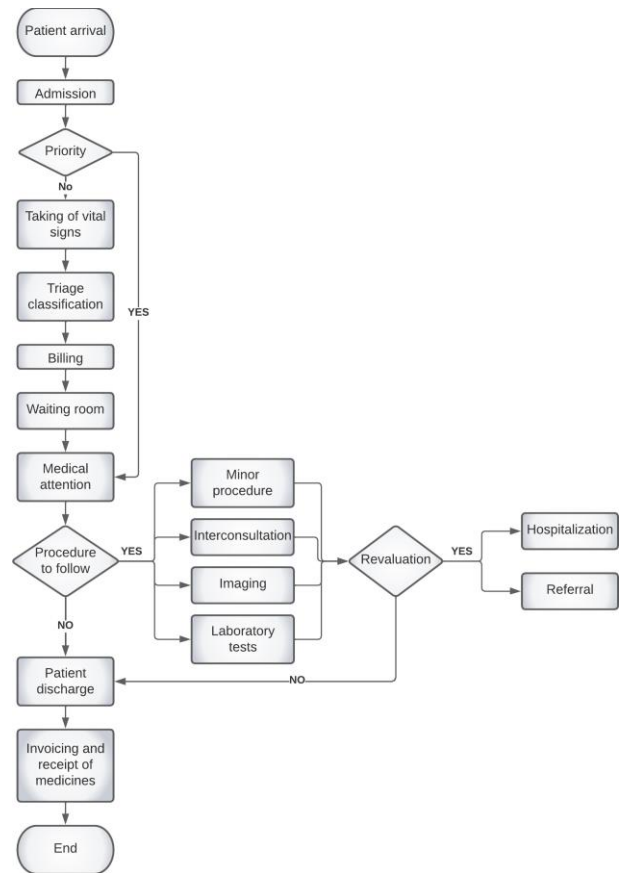


Fig 2: Flow Chart patient care in the emergency department

An increase in delays in emergency care times has been identified, causing delays in the treatment of patients and putting at risk the lives of those who require immediate attention, in some cases with patients having to wait from ten minutes to five hours.

Through the analysis of the information and user service system (SIAU) from January to December 2021 by the hospital within the quality management process, the subprocess of the analysis of the status of PQRS, satisfaction surveys, checklist, addressing people, the opening of mailboxes during the year 2021, it is possible to find the following data.

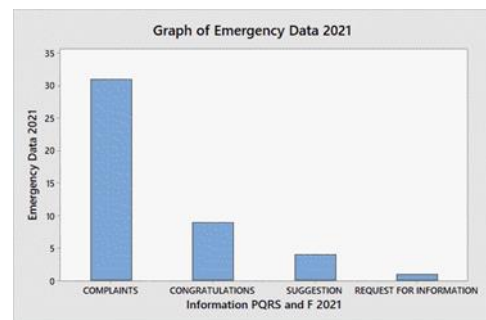


Fig 3: SIAU analysis report January-December 2021

A total of forty-five formats of requests and complaints are obtained, distributed in thirty-one complaints, nine congratulations, four suggestions, and one request for

information. The following is a percentage distribution for the year 2021 of the aforementioned formats, highlighting that 69% are represented by complaints, 20% by congratulations, 9% by suggestions, and 2% by requests for information, figure 3.

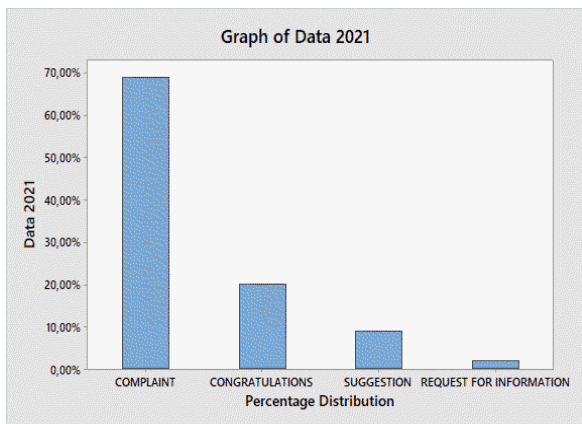


Fig 4: Percentage distribution PQRS Y F 2021 formats

In the year 2021, the hospital received a total of 21,013 patients, distributed as follows.

Table 1: Patients in the Emergency Department in the Year 2021

MONTH	PATIENTS IN THE UNIT
January	1630
February	1577
March	1962
April	2003
May	1968
June	2013
July	2066
August	1707
September	1654
October	1610
November	1431
December	1392
TOTAL	21.013

Observing an average monthly ED flow of 1,751 persons, between the different triage levels based on the following equation 2.

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n} \quad (1)$$

$$\bar{x} = \frac{21.013}{12} = 1.751 \quad (2)$$

The greatest demand for emergency services is because this is the main healthcare centre of the municipal capital and its surroundings, and it is here where sometimes the admission or waiting room is the result of the delay in care, generating discomfort inside and outside the emergency area, since this interferes with the activities of other patients, delaying the care that should be provided to all.

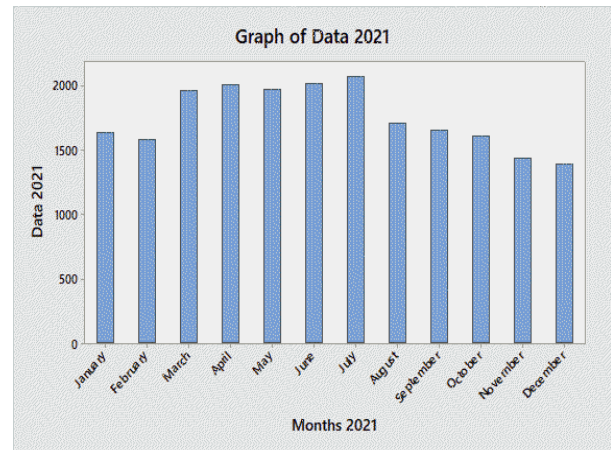


Fig 5: Service demand 2021

Below are the average patient care times at the three stations assessed throughout the year 2021.

Table 2: Average Times

Month of year	Entry - Registry	Registration - Triage	Triage - Exit
January	0:23:22	6:26:06	11:31:08
February	0:10:15	11:00:32	17:21:54
March	0:19:48	10:47:19	16:44:19
April	0:16:23	9:47:55	17:00:55
May	0:14:01	10:57:16	16:45:19
June	0:19:58	8:10:51	14:14:16
July	0:07:23	12:03:50	19:44:13
August	0:12:48	5:18:56	12:01:02
September	0:14:30	6:15:15	12:20:00
October	0:19:49	6:16:37	12:15:36
November	0:15:02	5:16:47	10:53:47
December	0:17:37	5:42:11	11:28:59

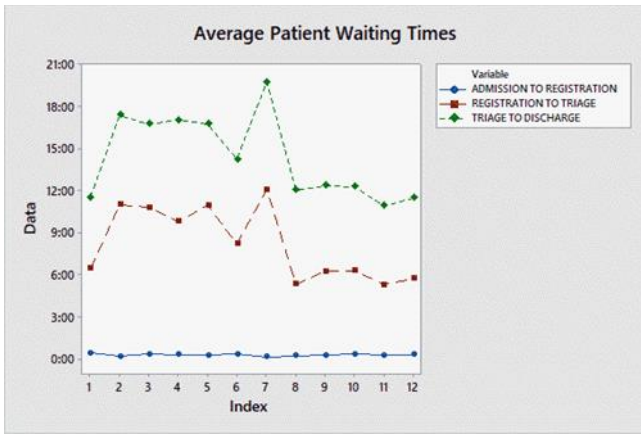


Fig 6: Average times

In figure 6 it is observed that the average times from admission to registration remain constant compared to the times from registration to triage and from triage to discharge.

The average times from registration to triage vary greatly in January, February, May, June, July, and August. Starting with an average of six hours in January and increasing by eleven hours in February, in May with an average of eleven hours and decreasing to eight hours in June, in July this time increases to twelve hours and in August it decreases to five hours on average, from here on from September to December the average time remains constant between five and six hours.

This station can be considered one of the most important within the process that each patient must carry in the emergency unit, since it takes time from the moment the patient is registered in the unit until he/she receives his/her respective triage, understanding this as the determination of the priority with which the patient arrives to the emergency unit and which procedure should be followed according to the physician's recommendation.

Taking into account the last station from triage to discharge, the average times vary a lot because here it must be taken into account that not all patients follow the same procedures, some go to the observation room for a short time and others go to hospitalization, which is why the times here can be days.

Using the data collected and taking as a reference the month with the highest number of patients attended, it is possible to establish the maximum number of patients attended in a month to take the times and routes of these patients.

The month with the highest number of patients in July with a total of 2,066 patients.

Table 3: July the Month with the Highest Number of Patients

Level Triage	Patients	Admission to the Registry (h.m.s.)	Registration - Triage (h.m.s.)	Triage - Exit (h.m.s.)
1	34	00:16:26	02:08:39	13:17:46
2	273	00:15:03	14:45:28	32:53:24
3	1754	00:06:23	11:19:31	17:34:45
4	5	00:22:53	00:03:59	02:27:43

Table 4: Average Patient Time in Min

Level Triage	Patients	Admission to the Registry (h.m.s.)	Registration - Triage (h.m.s.)	Triage - Exit (h.m.s.)	TOTAL (Min)
1	34	16	128	797	941
2	273	15	885	1973	2873
3	1754	6	679	1054	1739
4	5	23	4	147	174

Taking into account the criteria for triage classification in emergencies established by the Ministry of Health and Social Protection, those persons in triage level 1 should receive immediate attention from medical personnel as this is established as a priority. Patients belonging to triage level 2 should not exceed 30 minutes from admission to medical attention.

As shown in Table 3, patients belonging to triage levels 2 and 3 exceed the minimum time established.

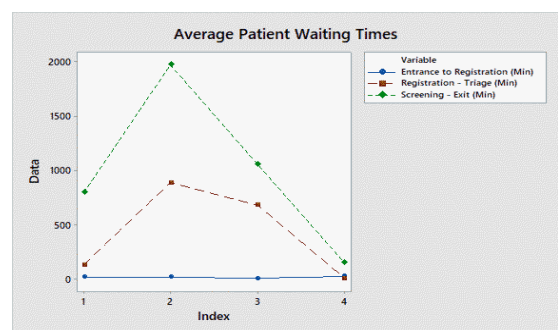


Fig 7: Average patient care time

Through the information gathered in the interviews with the medical staff and taking into account the average times, it is possible to establish that the greatest flow of patients is in admission, registration, and triage since these are mandatory steps to follow for people entering the emergency unit. It is important to point out that the great accumulation of patients and accompanying persons occurs in the waiting room due to the reduced space available in some of the hospital's areas.

As a result of the average waiting times for patient care, 3 critical processes were identified, from patient admission to registration, from registration to triage, and from triage to discharge, due to the time patients must wait to move from one process to the other.

B. Identification of factors that cause delays in patient care

Nowadays, organizations need to develop functions or processes in an optimal way to reduce or eliminate errors, repetitions, and defects or to save time and costs. That is why it is important to analyze in detail the root cause using various tools that have a direct impact on the activity not being performed correctly and failing. This paper uses a causal tree graph as an analysis tool, as shown below.

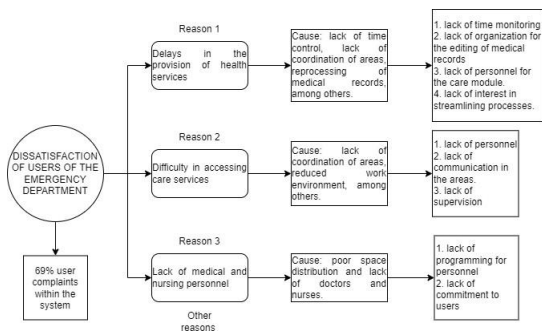


Fig 8: Causal tree

Root cause analysis is the use of various methods to determine the cause of an undesirable situation. [10]. The goal is to employ objective thinking and be able to figure out why something went wrong or why something could not happen [11]. In figure 8 The causal tree shows the 3 main reasons for complaints, showing the first and second-level causes and the root causes.

In interviews with the nursing staff and with some members of the ethics committee, it is possible to identify the causes of the complaints presented by the patients when receiving the service provided.

The main and most common cause is the delay in the provision of health services, difficulty in accessing care services, and dissatisfaction with the lack of medical and nursing staff; here patients refer to the fact that on many occasions the emergency personnel cannot cope with the number of patients arriving at the service. Another cause is

errors in care, lack of medical supplies, and inadequate distribution of space in the service.

Table 5: Causes of Dissatisfactions

Caused of Dissatisfactions	
Delays in the provision of health services	Difficulty in access to services
Dissatisfaction with lack of medical and nursing personnel	Errors in care
Lack of medical supplies	Inadequate distribution of space in the service area

Based on the current block diagram of the emergency department, it is possible to identify the activities to be improved and those that do not add value to the process.

The activities to be improved are fundamental within the process that each patient must follow to receive adequate care, but it is possible to observe an excess in the time of care, therefore, the one that should be eliminated is the one that sometimes takes time that can be used in those patients who require it by the medical staff. The discharge order can be simplified or oriented in another instance of the hospital without the need to alter the process of health service delivery.

Table 6: Activities to Improve and Activities to Eliminate

Activities to Improve	Activities to Eliminate
Waiting for patient admission to the emergency area	Wait for delivery of discharge order
Wait for patient registration	
Waiting for Triage attention	

Taking into account all of the above, the figure below is developed. 9, The Value Stream Mapping (VSM) with its Kanban bursts corresponding to Triage 2, which identify the activities to be improved and/or eliminated from the process carried out by the patient in the emergency unit. It is important to note that Triage 3 is similar to Triage 2, with a difference in the time required to provide the service.

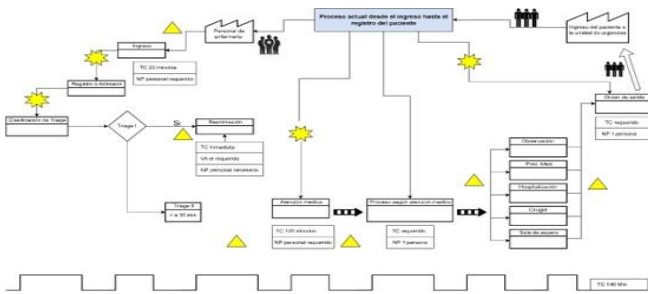


Fig 9: Value Stream mapping of the current process from patient admission to registration in Triage classification 2

The VSM shows the Kaban bursts, the cycle time (CT) which corresponds to the time that the patient takes to perform each activity, and (VA) is the added value, i.e. the time that is being invested to attend to the patient in each step of the process. In the case of Triage 2, the CT is 140 minutes

It is important to emphasize that the emergency unit does not meet the recommended space requirements, since it has a deficit in its areas and spaces for observation rooms, vital signs, medical office, stretcher, and wheelchair areas, and therefore requires improvements in its distribution.

C. Proposal to improve the patient care process:

The ability to improve the process is to increase the value using any strategy that allows you to solve the problem [12].

Taking into account the activities identified in the Value Stream Mapping and listed in the table of opportunities for improvement or as activities to be eliminated, the following are the associated proposals relating to the activities of:

- Admission of the patient to the emergency room until the registration or admission process
- Triage Classification
- Medical attention
- Process derived from medical care
- Delivery of the departure order

It is possible to relate improvement or elimination activities to the above-mentioned feedback:

- Patient admission: it was observed that the process of patient admission to the emergency unit generates delays in the care that should be provided to each person because on many occasions the security guard must fulfill other functions that do not correspond to his job, which generates a delay in the admission to the unit.
- Registration or admission: this activity is not adding value because the patient is asked for data that he/she has already provided to the nurses of the unit, which

is considered a reprocessing at this point. It is therefore proposed that this activity be carried out at a single point in time, i.e. during orientation, and then the nurse in charge should complete the clinical history with the missing information.

- It is important to implement software that allows full access to all patient information, minimizing the use of paper when vital signs are taken by the nursing staff available for each patient.

- Medical attention: the optimal service of medical attention depends on the availability of space required for each patient, which is why the best distribution of spaces will greatly improve the service provided by the E.S.E.

Taking into account 100% of the patients admitted to the emergency unit in July 2021, 2% are Triage I, 13% are Triage II, 85% are Triage III and 0.2% are Triage IV. It would be of great help to allocate 3 offices for Triage II, III, and IV care, giving priority to the care of those patients who, due to their level of criticality, require immediate attention and their treatment should be given in a specific office, which should be equipped to react immediately. Not all patients must be treated in the same office without differentiating the Triage as it is currently done.

- Process derived from medical care: due to the low number of nursing staff present in the unit, the patient must wait an average of 399 minutes for the procedures required. This is why it is important to verify the availability of nursing staff that can be relocated to this unit to minimize this time.

- Delivery of the discharge order: patients have to wait an average of 399 minutes for the discharge order, taking into account that some of them spent the night in the unit on the doctor's recommendation. The aforementioned software would be of great help in this step since the attending physician can establish online the recommendations and procedures to follow once he/she decides to discharge the patient, minimizing waiting times.

Taking into account the above, the improved process can be seen in Figure 10, below.

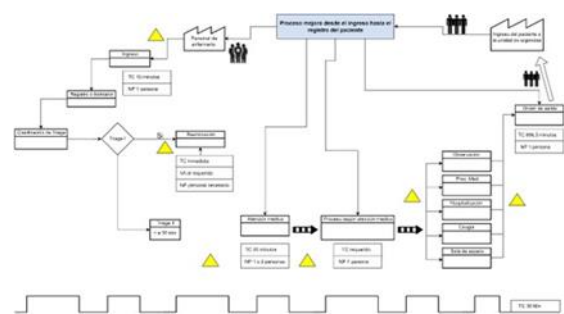


Figure 10: Block diagram improvement process

The figure above shows the general flow of the process to be followed by patients, it is also noted that the counsellor or person in charge of admission will be the one who will start the opening of the patient's medical history, then the taking of vital signs is performed and the patient is classified with the corresponding Triage, followed by the completion of the patient's information in Triage and the required medical care is provided and it is here where the attending physician defines the procedure to follow either hospitalization or discharge of the patient where he/she finally goes to billing and can leave the emergency unit with the medical recommendations made.

In figure 11 the proposed VSM for the admission of patients classified as Triage 2 is presented. In this, improvements can be observed in the waiting times of the patient admitted to the emergency unit. The waiting times for a procedure according to the Triage (2 or 3) in which it has been classified. These results are shown below.

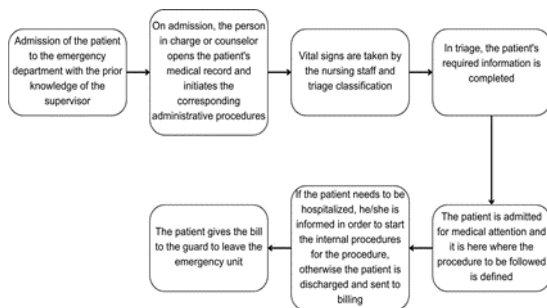


Fig 11: Value Stream Mapping proposed for patients classified as Triage 2

The figure above shows the proposed Value Stream Map, which shows reductions in waiting time for admission and medical attention, with an approximate reduction of 21% of the total time. In the case of the process from admission to admission, a reduction of 50% is estimated.

Approximately, this time will be verified since it is not possible to make a precise estimate as it will depend on the flow of patients and hours of service.

On the other hand, the process from registration to triage is intended to greatly reduce the waiting time of patients, aligning with the provisions of the Ministry of Health and Social Protection where it is established that the overall time of care of a patient classified as Triage 2 should not exceed 30 minutes, this due to the severity with which the patient has been admitted, taking into account this would go from having an average care time of 120 minutes to 20 minutes, considering a decrease of 17%, these times are also subject to the flow of patients arriving at the emergency department.

Table 7: Improvement in Current VS Propose VSM Waiting Times

Processes to be improved	Current VSM (Min)	Proposed VSM (Min)	%
Registry - Entry	20	10	50%
Triage - Registration	120	20	17%
Total Time	140	30	21%
	% Time Value Added		67%

The above table shows the time comparison between the current VSM and the proposed VSM, where the new total time will be 30 minutes, resulting in a time value added of 67%.

Another aspect to be taken into account is the redistribution of the emergency area, in which the plan is to allocate space for the storage of stretchers and wheelchairs, freeing up space in the corridors and not obstructing the shower area. Within the redistribution is to assign 3 more spaces for Triage attention, as well as the increase of specialized medical personnel in these offices, because at the moment there is only one office and only one attending physician for all the patients that enter the emergency area, which is why the waiting times are so high.

D. Control charts:

To evaluate the quality of the service, patient waiting times are studied using mean and variance control charts.

The values X1 Mod and X2 Mod are entered into the Minitab program to find the control chart mentioned above.

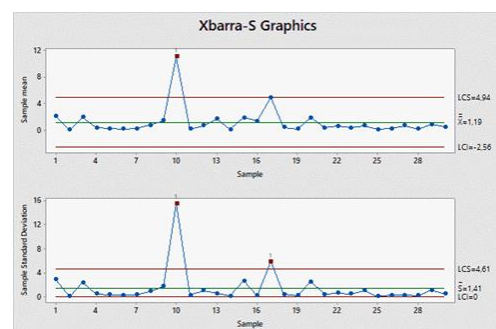


Fig 12: X-S graph

The interpretations of the results shown in the control chart are established through 3 steps, which are:

- Step 1: consists of determining if the variation of the process is under control, for this the S chart is checked to determine if the variation of the process is under control.

If the S chart is not under control, the Xbarra limits are not accurate.

In figure 12 represents the standard deviations of the subgroups. The central line is the average of all the standard deviations of the subgroups, in this case, is 1.41 and the control limits are Upper control limit figure 12 equal to 4.61 and Lower control limit equal to 0.

The red dots found in the graph are those points that indicate that the subgroups do not pass at least one of the tests for special causes and are not under control, in this case, we see present two red dots corresponding to 10 and 17.

These out-of-control points influence the process parameter estimates and prevent the control limits from accurately representing the process.

- Step 2: in step 2 we will determine whether the process mean is under control by examining the Xbar chart represented by the average of the measurements within each subgroup.

The average of this graph is 1.19 and the upper and lower limits are 4.94 and 2.56 respectively. As in the S graph, the red dots represent the subgroups that do not pass at least one of the tests, in this case, the same dots as in S, i.e. 10 and 17.

- Step 3: This step identifies which items failed each test. Minitab yields the following results at the end of the test: **Test results for the Xbar plot of X1; ...; X2**

TEST 1. One point outside 3.00 standard deviations from the center line. The test failed at point: 10.

S-plot test results of X1; ...; X2

TEST 1. One point out beyond 3.00 standard deviations from the center line. Test failed at points: 10; 17

If we look at the table corresponding to the sample extracted from the data provided by the E.S.E. concerning the times of the patients, it is possible to see that sample numbers 10 and 17 present a longer waiting time in X2, these being the highest times.

Table 8: High Waiting Times

10	242541	27/07/2021	0:06:58	22:03:01
17	241066	04/07/2021	0:46:18	9:03:20

With a time from admission to the care of 22 hours with 3 minutes and 1 second for sample 10 and 9 hours with 3 minutes and 20 seconds for sample 17.

3. Results

Current status of the processes in the emergency department. A structured interview was conducted with the

hospital's nursing and medical staff to establish the process that a patient must follow to receive medical care. 1, eight general steps are observed from admission to discharge order by the hospital, not including those patients admitted by ambulance or those classified as Triage I, because their level of complexity requires immediate attention.

Subsequently, a representative sample of patients, 30 in total in the month of highest patient demand in the year 2021, is taken during all hours and days, to establish which processes present greater congestion.

Table II The average waiting times in the emergency area according to classification II, establishing the times about the process from admission to admission or registration and from there to triage, where the patient is attended by the assigned physician. There is evidence of non-compliance with the times decreed by the Ministry of Health and Social Protection, which establishes a maximum of 30 minutes.

Using Lean tools it is possible to identify in which process the failures are found and how to correct them with the help of different tools that compose it. By restructuring the process to be followed by each patient, as well as the medical and nursing staff, it is important to delegate clear functions to provide quality and timely service.

In the different visits made to the service, it was observed that the first obstacle faced by the patient is the entry of security personnel, who are often not at their work site. Similarly, personnel problems were identified with the system or software used, leading to the registration being kept on sheets or notebooks, whose data will later be entered into the system, generating reprocessing and inconsistencies between the actual time of arrival of the patient and the waiting time generated when receiving medical care. Likewise, this system is little used and also old, so its functions are compromised in admission and billing due to the limited historical information.

There was evidence of duplication of processes and information in admission and triage, in which data and signs are taken. There is an excess of time that the patient must remain in the waiting room, before and after receiving medical attention. About the physical spaces, it was noted that they are not adequately used, nor are they properly equipped, as is the case of the medical office, which does not have a sanitation area or bathroom; on the other hand, the showers are used as a wheelchair storage area and the corridors as stretcher storage areas.

Taking into account the average times in the provision of the service to the patient, a Value Stream Mapping is carried out, considered one of the main Lean tools, since it allows visualizing, using Kanban bursts, the activities that do not generate value. In figure 9 the current Value Stream Mappin shows the processes that require improvement

from admission to registration and from registration to triage, process according to consultation and patient discharge order.

The ideal would be 3 for each level of Triage, but having at least 2 would reduce the waiting time for care.

In the block diagram proposed in the improvement (figura 10) The reduction of activities to be performed by the patient to obtain the service is observed, preventing reprocesses, which was possible through the application of Lean tools such as VSM, Poka Yoke and block diagram, identifying duplicated processes and paths that do not generate value to the patient.

When comparing the proposed VSM with the current one, an average time reduction about the total time of 21% is evidenced, reducing the time the user spends in the facilities, which is beneficial for both the patient and the hospital, as well as for the personnel involved. Since there will be a decrease in the congestion of all the spaces within the emergency area, especially in areas such as registration, admission, and triage.

There is a 50% improvement from admission to registration and a 17% improvement from registration to triage.

4. Conclusions

Care in the emergency area of the case study hospital for triage levels 1,2,3 and 4 currently generates large queues for patients and waiting times that increase day by day as the hours go by, in some cases reaching double or triple the maximum times established for the care of patients assigned in a certain priority.

On some occasions, patients may spend hours inside the service and this is reflected in the table below. III the month of July where averages of the attention times are obtained depending on the triage and the process in which the patient is in.

Through quality tools such as SIPOC, VSM, and control charts, it is possible to generate proposals that seek to reduce waiting times within the facilities of the emergency area, such as the characterization of all processes in the emergency area through graphs which allows visualizing, analyze and improve the flow of production, improving the capture and analysis of information that occurs during a production process, detection, and elimination of errors in logistic and production processes in the health sector guaranteeing quality services, as well as better understanding the role of decision making to observe if the process is within its random variability or has gone out of control producing failures that can be assigned to a certain problem. These strategies allow for reduced attention times.

The analysed case presents positive results, allowing it to be a reference for health entities that wish to evaluate the Lean methodology and the application of its tools.

The research conducted and the literature search towards the application of Lean in the health area allows us to evidence and corroborate that there is a need to improve the processes involved in the care provided to patients to increase the quality of service.

The case study evidenced the lack of commitment on the part of the entity to improve the care provided to the population and how there are currently methodologies that allow correcting errors in the services provided.

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