

The implementation of Lean Healthcare six sigma in a Public Hospital

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Abstract. The area of health has made considerable advances in terms of research and practices related to improvements to its management and search for quality. In continuation along this path, many hospitals have invested in the implementation of the Lean Healthcare Six Sigma (LSS) as a means of reaching such improvements. Due to this importance and noting that many of these initiatives are generally carried out through consultancy by members external to the hospital, the present work seeks to carry out a diagnosis of the situation in the hospital and propose improvements in order that the hospital team itself receives training and is able to perform the necessary improvements. To this end, a partnership was made between a Brazilian public university and a public emergency hospital located in the metropolitan region of the capital of the state of Goiás in Brazil, and which was registered as a research project within the university to which it is linked. The methodology LSS applied by action research based on PDCA with students, professors, and hospital team. The main result presented in this article is the Plan of a framework proposal of the Project, the diagnosis made followed by the proposal for improvement LSS was served as the basis for the contingency plan to support the fight against the COVID Pandemic. The implementation of Lean Healthcare Six Sigma in the hospital, parts D, C and A, will be presented in future publications.

Keywords: education, healthcare, hospital management.

1 Introduction

Standardization is vitally important mainly when dealing with questions related to health. In Brazil, Ordinance 2048 [1] established standardization for attending to urgencies and emergencies, as well as the creation and restructuring of pre-hospital care. This ordinance also focuses on the training of human resource personnel in attending to urgency and emergency situations, as only with well-trained individuals is it possible to implement standardization. Another important aspect when working in the area of health is patient safety [2], where the National Policy for the Humanization

of Care and Management of SUS (Unified Health System) was established through the Ministry of Health (MH), which used the Manchester Protocol as a support procedure mechanism. In accordance with this policy, in the triage and reception of patients at the hospital units, the patients are attended based on the severity of the illness, which is identified by color coding system. For example, the color red is considered an emergency assistance, while the color blue an urgency case, therefore the patient identified with the color blue will be treated after the other identified with the color red, and the waiting time will be defined according to current demand. According to the Manchester Protocol [3], the time of attendance to emergency cases, denominated as red color, should be immediate; very urgent cases, orange color, should be attended to within 10 minutes; urgent cases (stable patients), yellow color, the time is up to 60 minutes; standard cases, color green, up to 120 minute; non-urgent, color blue, 240 minutes to be attended to.

The classification of risk, established by the MH and the Manchester Protocol, has gone on to be defined at the door of the emergency unit of Brazilian hospitals [1], nonetheless, it is not clear which activity flow should be followed for attendance within the hospital. Therefore, improvements aimed at quality of processes and their standardization are fundamental. One way of achieving this is through the Lean Healthcare Six Sigma methodology, which can be used for improving processes focused on patient flow [4], [5]; reducing waiting times attendance [6], [7]; reducing risks [8]–[11]; in addition to reducing the Length of Hospital Stay (LOS) [12], [13].

The LOS reduction influences in treatment protocols [14], as in cost performance indicators, resource efficiency, and those which allow for hospital management [10], [15]–[20]. Another factor considered as a challenge to patient safety is the area of human resources, where it is very important that these be involved in the improvement process of hospital management based on training [1], a factor that generates the sustainability of improvements. Undeniably, this factor is critical to the success of the Lean Healthcare Six Sigma methodology, which contributes to continuous improvement and dissemination of knowledge [21]–[25].

Lean is a thinking dynamic methodology to less waste with less resources, it come from the automotive Japanese industry type as Lean manufacturing with methods such as 5Ss (sort, set in order, shine, standardize, and sustain), Kaizen, to Lean Healthcare [26], [27]. The six sigma was developed in United States from too an automotive industry to reduce variability of the process. So, Lean Six Sigma provide value for business with novice users reducing time for quality improvement [26]. Most of LSS application use DMAIC (D-Define, M-Measure, I-Improve, A-Analyze, C-Control) or PDCA (P-Plan, D-Do, C-Check/ S-Study, A-Action/Adjust), similar methods to apply continual improvement of processes. It is a cycle continual method to improve actions, action plan, to reduce costs, LOS, variability of indicators to standardized process [27],[28].

In this sense, in order to verify the behavior employed in the emergency department of a Brazilian hospital, located in the state of Goiás and maintained by the state government, the proposal was put forward for the implementation of the Lean Healthcare Six Sigma as set out in the PDCA cycle [29].

2 Methods

In order to carry out this project, the action research methodology was implemented, this is a qualitative method where there is a direct influence from the researcher on the study object. The researcher, in a cooperative manner with the participants of the action, pursues a resolution to a problem from continuous improvement through generating knowledge production [30]. The Project had as its proposal to develop an implementation framework for Lean Healthcare Six Sigma by the very hospital team itself, with the aim that this could be implemented in other public health units.

For carrying out the project, an agreement was reached between the education institution and the hospital. Subsequently, a training lecture was given by the professors of the under-graduation institution based on the theme of Lean Healthcare for hospital staff.

The research project was carried out in a public hospital, at the metropolitan region of Goiânia (Goiás Capital of Brazil), in the emergency area which performs general, maxillofacial, and orthopedic surgeries, as well as providing physiotherapy, nutrition, psychology, nursing care and social work services. The hospital has almost 700 employees, more than 90 beds, performs 3000 imaging tests per month, more than 600 emergency care performed in the emergency room per month, and 700 outpatients with a goal of reaching approximately 1000. Hospital services are provided exclusively via SUS (Unified Health System), and the hospital selected for the study was one of the hospitals chosen during the Covid-19 pandemic period to receive patients with this disease. The project followed as its support method the PDCA cycle to develop a framework to improve LSS by education hospital team to sustainability continuous process improvement, see fig. 1. The PDCA method was applied to answer some questions: What is the purpose of the project? What are the problems to be solved? What will be measured, and how to measure if the problem has been solved? What are the necessary changes? [27],[31].

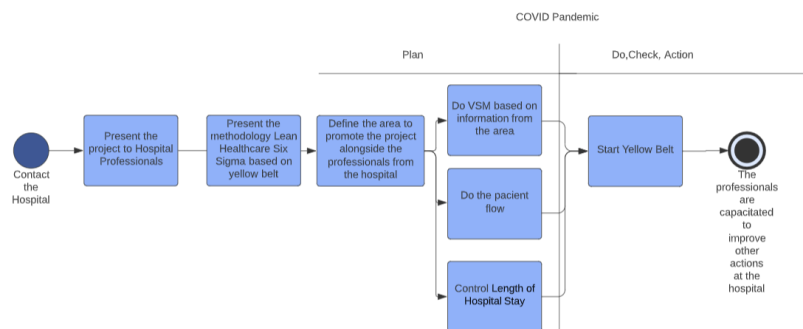


Fig. 1- Project Diagram

The first part of the Project, see fig.2, the Planning stage, was performed in the emergency unit, an area considered by the hospital team as a more critical area and which needs to be given priority, since the hospital primarily serves Emergency and is connected to the State network. In this step, the tools, Hospital Activity Flow,

Emergency Value Stream Mapping, and gaps from the care of patients registered during an emergency care period were used, selecting the morning period of a Wednesday in December 2019.

In order to arrive at a resolution of the actions to be taken by the team, the proposal was put forward of the elaboration of a Yellow Belt training [10] for the hospital staff in order that they receive adequate qualification, so that they can implement the project and themselves would be able to promote self-improvement (Kaizen - continuous improvement), the proposal framework, see fig.2.

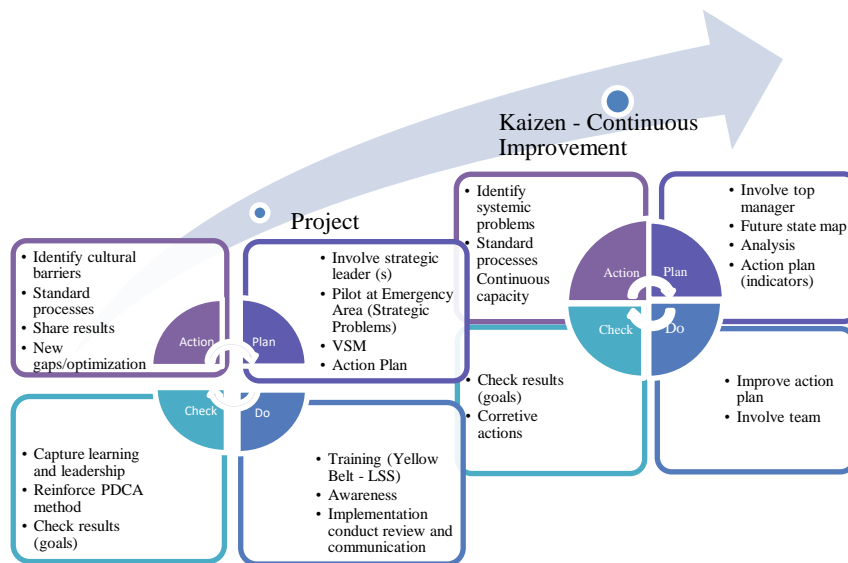


Fig. 2 – Proposal framework

March 2020, the Covid-19 pandemic began and changes were made as to the way the project was conducted. The first was to stop the project, and then the dates collected from the first step, that of Plan, was integrated to develop, together with the hospital, the contingency plan to support the fight against the COVID Pandemic. The hospital thus became part of the COVID care network in the state of Goiás, Therefore, the part of training the human resources department of the hospital for the implementing of improvements, as part of the Lean Healthcare Six Sigma project, was left as a future stage, that is, post-COVID.

3 Development

In the PLAN stage of the pilot project, the part of identifying problems, the Capacity plan was elaborated in a way as to identify factors that generate overcrowding, see fig 3.

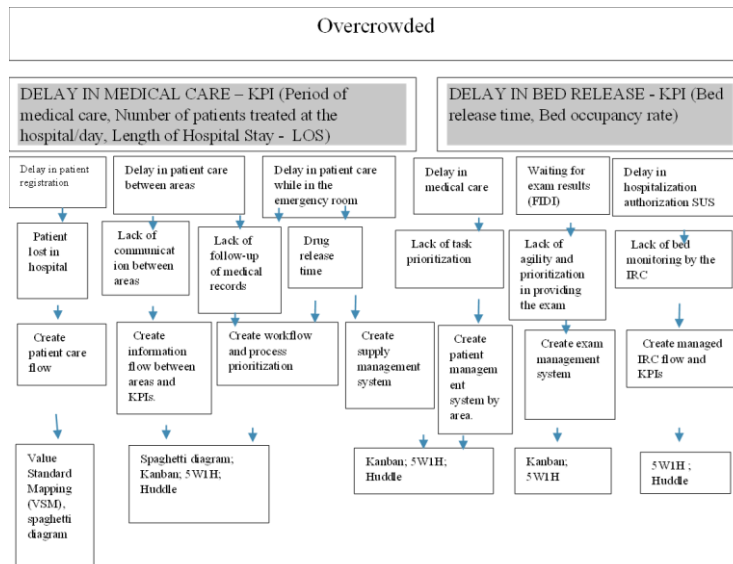


Fig. 3 - Full capacity plan

From the full capacity plan, the patient flows were established, see fig 4, where in the first stage of the patient flow, the patient is registered upon showing their official documentation, their SUS health card, and providing personal data. After performing registration, risk classification is performed, according to the Manchester Triage System [3], which is performed by a nurse. Only in two cases do the patients not go through classification, these are cases where the patient enters via ambulance, where the patient is attended to directly via emergency, and documentation is sent over to registration.

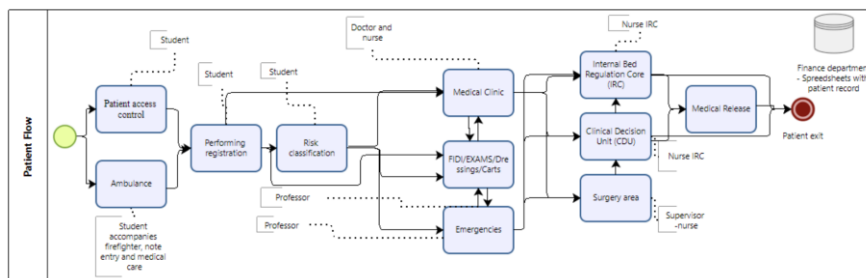


Fig. 4 - Patient flow within the hospital system

The other case is due to patients who were attended to via emergency and who were referred, after discharge, for medical clinics or to undergo tests. In these cases, the patient only goes through registration and is then sent to the exams area (FIDI) and medical clinic area.

After performing registration, risk classification is performed, according to the Manchester Triage System [3], which is performed by a nurse. Only in two cases do the patients not go through classification, these are cases where the patient enters via ambulance, where the patient is attended to directly via emergency, and documentation is sent over to registration. The other case is due to patients who were attended to via emergency and who were referred, after discharge, for medical clinics or to undergo tests. In these cases, the patient only goes through registration and is then sent to the different type available hospital exams (FIDI) and medical clinics. After having their classification performed by a nurse, the patient is sent to the emergency, in accordance with the color or level given by the Manchester Triage System that attends to their needs. Once attended to by the doctor, in the emergency department or medical clinic, the patient is sent to the analysis laboratory, imaging, dressing, casts or is sent directly to clinical decision unit (CDU) for administration of medicine and, in some cases, to stabilize the patient, in other cases the patient is directed to surgery or hospitalization or even hospital discharge. When the hospital attends to cases that are not part of the hospital specialty, these are sent, in accordance with availability of beds in the State, to another hospital that has a place.

Following this, the patient flow was defined, and as laid out in the Full capacity plan, emphasis was placed on the need to perform a pilot collection, in a way that collects data for surveying times and problems inherent to patient care. In the patient flow, see fig 4, the team attending to the patients during the time at hospital up to departure from the hospital was inserted. The entire team accompanied all the patients who were admitted to the Emergency Room from 8 am to 12 noon on December 4, 2019, totaling 36 patients who were monitored from their arrival to their departure from the hospital. For patients who were hospitalized or who were still receiving care after 12:00 am, their forms were followed up and filled out by the hospital staff who were working directly on the case. Based on these data, various analyses were performed along with the Value Stream Management, see fig 5. For data collection, all members were presented with the spreadsheets that would be used until the time of patient discharge, as well as for following up the patient medical record, which accompanies the patient, in physical format, across all procedures performed within the hospital.

The pilot project simulated what happened on the day of data collection for hospital care, which is why those responsible for monitoring the medical records, presented in each area, were included, as the hospital does not have a system for patient monitoring, only for monitoring the services that must be presented to the SUS for payment.

Through the data verified on VSM, an analysis was performed for the Length of Hospital Stay (LOS), Value-Added-Time (VA) and Non-Value-Added Time (NVA) and a sweep was made to verify their correctness, as time wasting of the patient was already known, but had not been quantified or verified as to where they were concentrated. With this data at hand, checks were made into time averages of how long patients wait in a given area, as well as time the patient remains without changing over to another type of care within that area. Through the implemented monitoring procedure, various points that could be improved were exposed.

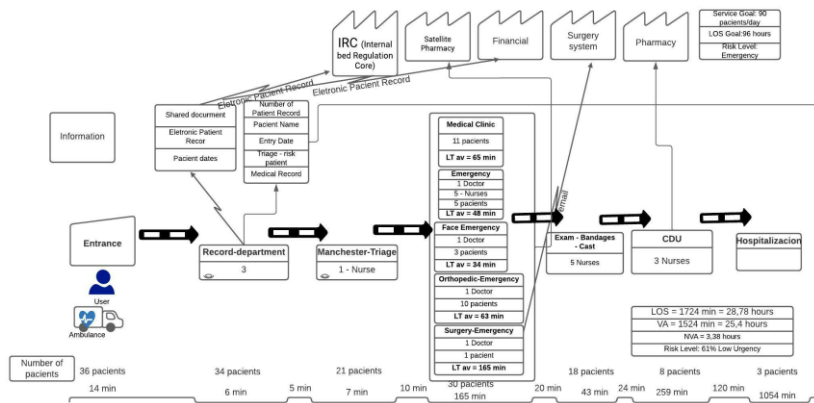


Fig. 5 - Current VSM for patients in the study

The maximum LOS reached 28.78 hours, which is lower than that defined by managers in the state of Goiás that contracts the hospital service, which is 4 days, as well as the maximum VA. However, there was a NVA of 3.38 hours, if the specialty of the hospital is analyzed, that of emergency, where this waiting time can lead to the severity of the case in this patient, a factor that was analyzed in terms of patient safety.

In order to work with the Lean Healthcare Six Sigma methodology, the first step is to work on the NVA, with the longest waiting times being verified from among first-care areas. Among the principle problems encountered, the following are highlighted: patients who were lost inside the hospital, not knowing where they had to go; mismatch between the patient and their medical records, and there were cases in which the patient arrived before their medical record; error in labeling the medical record, which can lead to confusion between the name of the patient and their medical record; long waiting time for service; delay in transferring to another unit when necessary, among other problems.

Noteworthy here is that the problems raised refer to monitoring performed on 36 patients, i.e. if the number of patients followed up had been greater, probably more problems would have been detected. However, based on these data, various points for improvement were detected.

Another identified area of time wasting, NVA, was the maximum waiting time between Emergencies and the Medical Clinic, for medical exams, plaster casts and dressings, totaling 20 min of waiting, as well as in forwarding the patient to the clinical decision unit (CDU), where the patient receives medication, which was 24 min. In addition to this time, the transfer of the patient from the clinical decision unit, the patient support point to the hospitalization sector, had a waiting time of 120 min, with the responsibility for the operation of physical and virtual beds (stretchers) linked to Internal Bed Regulation Core (IRC).

In the VA part, fig 6, the IRC was the biggest part, 43% of the LOS average, and when the hospitalized patients were verified, the patient with the longest stay was on hold to be transferred to another hospital connected to the state network and which focuses on the problem defined for the patient. In the clinical decision unit, 33% of the

LOS average, the longest waiting time is due to a patient waiting for surgery, a patient who was referred by the emergency-surgery unit, with a time of 259 min. This value actually needs to be worked on, and it was also a factor that was also verified in a patient who had been hospitalized for 16 hours, considered as IRC waiting to be transferred to another hospital in the State network.

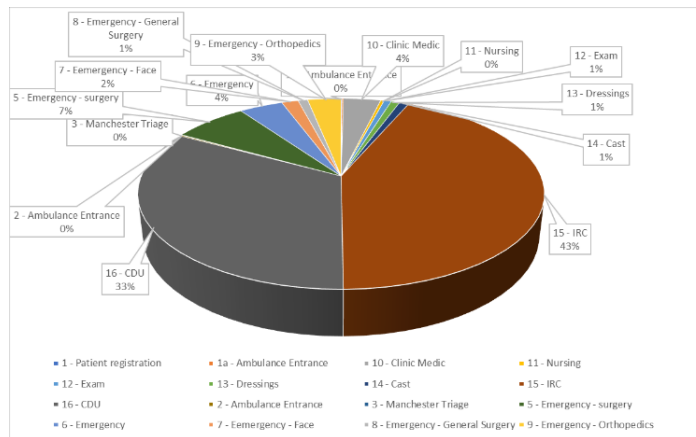


Fig. 6 - The percentage of time spent by patients in the hospital.

Another factor analyzed based on data from the pilot collection was the time spent by the patient without movement within the areas, as shown in the Pareto diagram, see fig 7. Around 80% of the time is in the care area of Emergency-surgery, and for performing dressings and plaster, as well as facial fracture emergencies, and the ambulance entrance, consider priority for emergency.

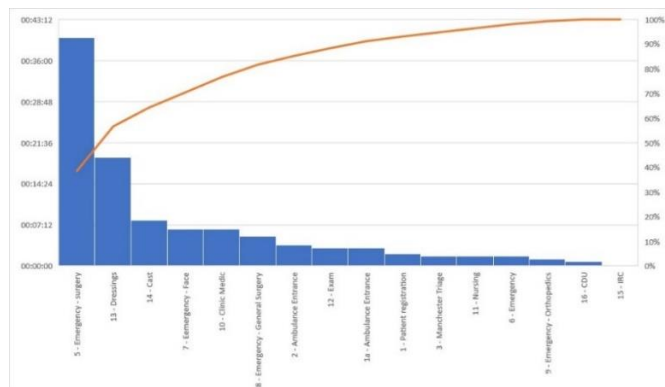


Fig. 7 - Pareto chart from average time spent without patient being movement on.

In the analysis of data for the months of care studied at the hospital, it emerged that even though the hospital is intended for emergency cases, 61% of the cases were focused on non-urgent care, a factor that also needs to be analyzed considering the health network of the state. Based on the verified gaps, an action plan was proposed, and

together with the hospital team participating in the project, recommendations were made as to those areas that should participate in the Yellow Belt training. However, with the COVID Pandemic outbreak, this planning became the strategic plan of the hospital for coping with the pandemic. In the following, Table 1 presents the Full Capacity Plan to avoid Overcrowding, and the Action Plan, for generating points of attention in the contingency plan for COVID.

Table 1 - Action Plan for Full Capacity

What is to do?	How?	Why?	Where?
Long time to Register the patient	Train workers	Improve time for patient registration	Registration department/ Manchester Triage
Patient does not know where to go	Lower the time for patient registration at hospital entrance Communication inside the hospital with patient was improved	Build the patient record Buid patient communication system	
Lack of follow-up of the medical record	Communication between departments inside the hospital was improved	Information concerning patients that are waiting in each department for attendance	Emergency
Failure in LOS at emergency without relocation	Disseminate the need to complete the Anamnesis Questionnaire Build flow relocation patient record	To manage or treat disease Improve the record - patient management	
Lack of time at administration at clinical decision unit (CDU) without relocation	Build Kanban at emergency	Develop system management record	CDU
No of exam return given	Develop kaban at clinical decision unit (CDU)		
Prolonged length of waiting time for dressings	Develop Kanban for exam department	Improve exam response time	FIDI
Prolonged length of waiting for cast	Follow flow patient record	Improve attendance response time	Dressing Cast
Prolonged patient transfer for another hospital in the health network in the state of Goiás	IRC - improve transfer process IRC - Do Benchmarking with another hospital	Improve number of beds released in the hospital	IRC
Manage a system to control the hospital	Maintain daily Huddle for implementation COVID rows (aspects of structure, systems, human resources, suppliers, services and assistance are evaluated)	Improve overall quick decision-making system	Director
Need for indicators that regulate contingency levels	Build daily indicators	To allow management of levels in an agile way	Quality Department

Apart from the contingency plan, a strategy was formulated that was aimed at decision making processes regarding the management of human resources, materials, and the bed from the health network in the state of Goiás. This strategy was created for routine operation, levels 1, 2 and 3, up to overcrowding, these levels were created to

allow for a facilitated decision-making process by the different areas of hospital management. These levels subsequently change as the resources controlled by the Contingency plan are used and not replaced.

If the number of patients hospitalized with COVID sits between 63 and 72, the hospital leaves the Routine level and goes to Control Level 1. These levels were controlled, both for the stock management sector of products considered necessary for the operation of the hospital against COVID-19, such as cap, mask for patient and operation, apron, gloves, as well as respirator, respiratory ventilators, as part of bed operational management, in addition to the Intensive Care Unit (ICU) sector.

Another part considered in the contingency plan, which followed the levels of care defined by inputs and by beds, was the part of area management; this included the Board, IRC management, exams, human resources, pharmacy, quality, and patient safety. Each area had its actions set in accordance with each level that the hospital entered; this was created in the search of improved operations in both patient safety and human resources and was seen through the hospital management working together with state network. In this scenario, the entry of new patients was blocked, via the network, the moment the hospital entered into Level 3. In this operational action plan by Table 1, the hospital managed to operate at around 90%, with its operation open to the network over the period of March 2020 to January 2022.

4 Discussion and conclusion

The study herein was performed for the implementation of Lean Healthcare Six Sigma (LSS) in the sense of improving hospital operations. As such, the collection of data implemented demonstrated the efficiency of the VSM tool [20], which through its verification of patient flow [4], [5], was shown to be fundamental in management and patient safety, with the presentation of VA and NVA time, in addition to LOS [13], [33], since LOS is entirely affected by NVA. From the analysis of the collected data and from the depth problem, the Pareto Chart managed to present the main bottlenecks associated with patient entry into the hospital, which are a major factor in patient risk management through standardization of the process, as well as the control indicator NVA. The lack of standardization in processes [14] was found to be an important factor in the accuracy of treatment given, as well as patient safety.

Another area considered in the article was the need for performance indicators, such as LOS, VA, service time of areas, waiting time between areas, in order that proper planning of a hospital occurs. Planning of this kind includes factors that generate agility in responding to rapid changes, such as responding to a Pandemic. These items could only be employed by the hospital, as presented in the project, based on the implementation of Lean Health Care Six Sigma.

Reliable data was defined as that which from its analysis allowed for the desired goal to be reached. This goal was established by the hospital at the beginning of the pandemic, with a full capacity plan and a contingency plan, which consider knowledge of issues that could be successively analyzed over time and that allow for a diagnosis of the condition of the hospital in view of its operation [14]. These factors go on to

define the management plan that will be followed by each manager in view of the stage that the hospital faced during the pandemic and using its standardized indicators for COVID care.

The relevance of the study toward the implementation of the LSS methodology was seen by its capacity to verify in a short time, performance indicators that were not known by the hospital and that proved to be extremely important in the management of the patient and their safety. In addition, indicators and actions were generated that were shown as necessary for hospital management. The period of care, patient flow, management definitions to be followed allowed for the standardization of the process for each area manager. This standardization was reached in view of the stage that the hospital faced during the pandemic and its standardized indicators for care and decision making in view of the situation of human resources, materials, and hospital equipment for COVID.

To start the project the university group had some challenges, as need to wait more than six months to do the pilot, and to collect data for the VSM. The first part of the project was the accordance between the public hospital and public university, after the Ethics platform, that almost six months to do. This time became brought the group together, university and the hospital, gestion and areas coordinators that were a challenge.

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