DMAIC for Process Digitalization: A Hospital Case Study

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ABSTRACT

Purpose - This paper presents how to implement the DMAIC cycle as an element to X-ray the progress of a digitalization initiative focused on the ambulance's request system for daily transport of patients initiated in a Portuguese hospital, which was not achieving the expected results. The research has the goal of not only contributing to the literature on the application of the Lean Six Sigma methodology to healthcare operations but also, of giving practical recommendations on how managers can leverage on the same approach, and apply the concept in their internal process improvement initiatives to reduce friction in digitalized processes. Ultimately, it is shown how a methodology like DMAIC, presents in itself a great option to start and methodically lead a business process digitalization project.

Methodology - The authors chose to follow an Action Research methodology while approaching the problem at stake with the DMAIC framework.

Findings - DMAIC can be a relevant problem-solving structure to measure the success and support the digitalization of business processes.

Originality – The originality of this paper lies in the application of a logical structure such as the DMAIC cycle to analyze the quality issues inherent to the digital version of an ambulance's request system.

Practical implications – This case study depicts how the operationalization of digitalization initiatives using the DMAIC framework can be more effective while allowing organizations to adequately and actively react to the implementation problems. It presents improvements of 23% lower lead times for a redesigned digitalized ambulance's request system.

Keywords: Healthcare, Lean Six Sigma, DMAIC methodology, Digitalization

Paper type: Case Study

INTRODUCTION

Healthcare today is said to be evidence-driven. However, even though huge amounts of data are collected, clinical practice is often not governed utilizing these data for learning, improvement, and innovation. With this said, even though individual health care professionals are performing excellent and dedicated work, the provider might be flawed in its core and patient outcome is far from optimal, or even unacceptable. With multiple problems caused by human errors, it is paramount to raise the bar for processes, services, and businesses (Taner, Sezen and Antony, 2007).

As we witness the emergence of new technologies, reduction of financial support and more informed customers, an increasingly challenging and demanding environment seems to be an underlying paradigm for the future healthcare industry. These services must now focus, more than ever, on continuously looking for methods for optimizing process performance, with technology as a potential ally for decreasing operational costs, improve the speed of service, and reduce risks and errors.

The need for such improvement initiatives is rooted in the rising expectations from customers (which are the patients, their family, and friends) regarding the quality of care they receive. They are no longer willing to accept poor quality services, and suffer long waiting times, on the contrary requiring transparency, and high-value interventions, with a minimal cost. In this scenario, Lean Six Sigma (LSS) principles and tools have been used to tackle principal causes of inefficiency, reduce slack, and optimize operations. It should be highlighted that LSS, with particular emphasis on DMAIC (Define-Measure-Analyze-Improve-Control), is not only a step-by-step guide to understand and deconstruct problems in a manufacturing setting but also business-related processes (Mast and Lokkerbol, 2012). Its importance is based on a data-driven view of the problem, with statistics and general analytics being used to support and improve business decision making (see, for instance, (Kuvvetli and Firuzan, 2019)).

In light of this research, the authors of the paper present and discuss the key characteristics and results achieved of an LSS project developed in a Hospital, focused on the ambulance's request system digitalization initiative which results were below the expectations of the management team. It was deployed with the intent of understanding why there has not been visible progress on its implementation, and how much of the existing friction in the process could be mitigated. On top of this, it was also used to measure the impact of the potential digitalization of different steps, before any improvement foresight could be designed, while also looking for new ways to reduce the overall costs of the request system eliminating defective outputs which were identified along with the analysis.

RESEARCH METHODOLOGY

The paper presents a case study developed with an Action research perspective (Eikeland, 2012), where the authors worked closely with the parties involved in the process at stake. In detail, this section reports on the implementation of an LSS project in the Patient Management Department, with a focus on the ambulance's request system for patients with economic constrains or reduced mobility conditions in a Hospital of large size. Yearly, the Hospital performs around 2000 medical appointments/day, 120 surgeries/day, and a total of 5500 transportations per year. The project was developed over 3 months. Historical data was collected and analyzed before the beginning of the LSS intervention. Further data and information were collected and analyzed cooperating with the transport team in charge of the process and conducting several interviews with senior figures and professionals working in the Hospital and contacting daily with the procedure at stake. The main goal pursued with the LSS project was to increase physicians' productivity, reduce operational costs, and deliver services of increased quality. More specifically, the LSS project was aimed at reducing the resistance to the digitalization of the ambulance's request process and minimizing the errors associated with the requisition form. These errors lead to multiple problems, which are described and drilled down throughout this paper. DMAIC was selected to operationalize LSS and keep the different parties engaged, as subsequently discussed.

For the sake of confidentiality of the parties involved, the numbers presented in the paper may have been modified.

LITERATURE REVIEW

Lean Six Sigma:

LSS emerges as a viable option for improving performance at the level of effectiveness and efficiency, with particular emphasis on processes, within the reach of healthcare organizations (Bisgaard, 2009). Optimizing efficiency is one way for providers to control their costs without sacrificing the quality of the outcomes they plan to achieve.

Six Sigma is a data-driven process improvement methodology used to achieve stable and predictable process results, reducing process variation, risks, and defects. Snee, (2010) defined it as: "a business strategy that seeks to identify and eliminate causes of errors or defects or failures in business processes by focusing on outputs that are critical to customers". While both Lean and Six Sigma have been used for many years, they were not integrated until the late 1990s and early 2000s (Snee and Hoerl, 2007). Today, Lean Six Sigma is recognized as a business strategy and methodology that increases process

performance, with DMAIC serving as the compass to guide the projects to success (Koning and Mast, 2006). Lean Six Sigma combines the best of two distinct methodologies:

- Six Sigma, which helps in reducing the number of defects and the variation of the outputs, improving overall process efficacy.
- Lean thinking which helps in reducing the cycle and lead times, improving overall process efficiency.

Although the Lean Six Sigma approach has in the past predominantly been used to improve manufacturing processes, it is now increasingly been transitioned to a wide variety of non-manufacturing related operations. This is an important development, as there are potentially more advantages to be achieved in those areas than in traditional manufacturing where decades of good work have already paid off (Nave, 2002). The key to understanding how Lean Six Sigma can be applied more broadly is to recognize that non-manufacturing operations are also processes; they process inputs from suppliers and provide output to customers. Some applications of Six Sigma have been suggested in healthcare (Barry, Murcko and Brubaker, 2002; Heuvel, Does and Koning, 2006). In the last-mentioned paper, project examples are highlighted, concerning complexity reduction in hiring personnel, improving operating theatre starting times, and improving a maintenance system. However, there has also been some endeavors usually approached from the perspective of efficiency of the management of flows (see, for instance, Hanne, Melo and Nickel, (2009)), as well as some examples on DMAIC as a methodology to improve software development (see, for example, Karout and Awasthi, (2017)), little research has been executed with interest on how Lean Six Sigma can help in endorsing the digitalization of processes by measuring its impact on the elimination of waste, errors, and overall quality increase of the results produced. Also, it can be a driver for understanding the underlying factors that cause resistance to the transition to digital processes, by always using DMAIC as the compass for the project. Taking this in mind, the authors propose a new paper to continue to fill the gap in the literature related to how DMAIC as a problem-solving framework, can be used in digitalization initiatives, using LSS principles in its core.

DMAIC Cycle:

Based on the defined objectives, this project was conducted under the umbrella of the Lean Six Sigma methodology. The selection of the tool to solve the problem presented fell to DMAIC. DMAIC is systematic and data-driven providing a sound framework of results-oriented for end-to-end project management. The methodology may appear to be linear and explicitly defined, but it should be noted that the best results are achieved when the process is flexible, thus eliminating unproductive steps (Sokovic, Pavletic and Pipan, 2010).

The DMAIC (Define-Measure- Analyze-Improve-Control) methodology, works as a roadmap for problem-solving and process improvement, making it the best candidate for the problem presented throughout this paper. It will be used to tackle it in five phases:

1. **Define (D):** Define the problem at hands;

The main purpose of this stage is to clearly define the problem to be resolved with all parties involved or affected by it. There is also the goal of verifying if the action plan, deliverables, and timeline for the project to be started are aligned with the priorities in the organization and its business objectives. There must be support from the management and availability of required resources to achieve success (Abu Bakar, Subari and Mohd Daril, 2015).

It starts with clarifying the problem statement and the overall advantages for the business.

2. **Measure (M):** Quantify the problem identified;

To better understand all the processes in the organization, customers' expectations, suppliers' specifications, and identification of the possible places where a problem may occur, it is important to qualitatively and quantitatively define the problem at hand. This allows not only more data-driven decisions on how to move forward but also a better understanding of the process improved in the Control phase by benchmarking the same Key Performance Indicators. In this stage potential problems have to be proven to be real problems.

3. **Analyse (A):** Analyse the problem and identify the root causes for process imperfections;

In the analysis phase, multiple tools and methods are applied, taking into account the data acquired and treated in the latter stage, to find root causes, assess the risk, and prepare the ground for improvement measures to be proposed. In this phase it is needed to define process capability, clarify the goals based on real data gained in the measure phase and start root cause analysis which has an impact on process variability and the errors produced as the process is executed.

4. **Improve (I):** Propose improvement measures to be implemented to achieve the goals set for the project;

The goal of this stage is to take necessary information to create and develop an action plan to improve the functioning of the organization, financial aspects, and customer relationship issues. The possible solutions for the action plan should be presented to the team involved in the process and executed iteratively. Some kind of pilot solutions should be deployed on a risk-reward optimization basis, confirming the validity and accuracy of analytical work which allows making any corrections before carrying out the solutions on a large scale.

5. **Control (C):** Create mechanisms to help continue to measure the evolution of the changes applied to the process and guarantee their continuity in the future. Also, aims at building another step on the continuous improvement journey, making sure that the level of operational excellence achieved is set as the basis for further initiatives.

The control stage is about confirming if the changes implemented at the *Improve Phase* are sufficient and continuous by verifying the quality of the re-designed process. It also controls the future state of the process to minimize variation from the objectives and ensure that the correction is fully implemented before generating results misaligned with the business targets. Control systems such as statistical process control should be implemented. The process has to be continuously monitored.

Each of the phases D, M, A, I, and C encompasses in itself several steps and tools to be applied (Shankar, 2009), which will guide through the execution of the presented improvement project, from identifying the problem to measuring it, and correcting it taking into account the targets to be achieved.

CASE STUDY

The project first arises because of the need to reduce backlogs detected in the administrative processes within the Hospital, which were causing delays in patient-related activities, such as the lead time of accessing personal clinical records, or of receiving confirmation of the right ambulance at the right time to transport patients from their homes to the scheduled appointments, and vice-versa. This paper aims to describe a real case study focused on internal administrative processes presented by a Hospital's Senior Management team in Portugal converted into a Green Belt level Lean Six Sigma project and tackled using the powerful problem-solving framework - DMAIC, to diagnose the operations and understand where divergences from the documented procedures are happening, and, not less important, why they are happening. This supports the creation of new procedures and the re-design of existing ones.

In the end, it will be presented the analysis made to the process of scheduling ambulances for trials, exams, hospital stays, and medical appointments happening on the same day of the request. The project of digitalization of this business process, transitioning to an entirely paperless task, was not running as expected. This procedure was generating a lot of faulty requests, to mention a few:

1. The wrong type of ambulance;
2. Ambulance requested without the needed equipment for transporting a patient with a particular condition;

3. Requests made for the wrong time, or day;
4. Requests for transportation without having any link with a medical appointment;
5. Transports that were activated and paid for, but never happened in practice.

The goal was to redesign the process reducing the steps needed to register the request of a new ambulance, reducing defects and money lost with faulty requests. On top of this, to understand where and why the digitalization initiative was falling behind the targeted results.

The Hospital was testing the hypothesis of digitalizing most of the process activities related to the ambulance's procedure described above, to achieve 100% paperless requests in all medical wards. The problem was suffering from a lot of resistance from the parties involved (physicians, nurses, secretariats of the medical departments, etc). With it, the physicians were fully responsible for the end-to-end process of requesting an ambulance. Thus, the analysis done was also focused on endorsing this digitalization project with proposals to help the transition. Future yearly savings were calculated to support its scaling to all the medical specialties where patients needed transportation.

Phase 1: Define

The research study started with a meeting in the Hospital to discuss the problems to be solved. To clearly understand the situation and the underlying bottlenecks disrupting the expected workflow, more than 40 people were interviewed, from physicians to the secretaries of each medical specialty in the Hospital. On top of this, it was crucial to set a line between the current ambulance's prescription process (in a paper format), where the secretary of the medical ward was the central piece, passing the information from a physical form filled by a physician into an IT system, and the fully digitalized process, where the physicians were fully accountable for requesting an ambulance to transport the patient in the day of the appointment. This way a paperless process could be achieved. The digital request would then reach the "Ambulances team", which would follow-up with contracting a company to execute the trips needed, at the time needed, and issue the responsibility terms for the transportation of a patient.

To make sure, everyone in the team responsible for leading this project was aware of the goals and had the same level of understanding of the problem, a project charter was created and presented. The data needed to start was also defined and requested for senior management.

Problem Statement

- 2 years before this project, an initiative to digitize ambulance requests was initiated in a specific ward, where doctors were 100% accountable for the entire process of ordering them via an IT system. However, errors continue to be made in filling the request and unnecessary ambulances are called out. In the end time and money are wasted by the Hospital.

Benefits of the project

1. Cost reduction with unnecessary transports;
2. Reduction in the number of steps required to request a transport for the patient;
3. Reduction of errors associated with filling the transport request form;
4. Expansion of the electronic prescription method to other specialties;

Objectives

1. Measure the amount of unnecessary ambulance requests happening daily;
2. Diagnose the root cause of errors in filling out the transport request form;
3. Redesign the circuit so that these errors/problems are reduced, and if possible, eliminated;

Scope

- **1ª step of the process:** pedido de transporte por parte do paciente
- **Last step of the process:** Registration of the patient's departure and respective delivery of the ambulance's term of responsibility;

Outside the scope: communication between the Hospital and ambulance proprietary companies.

Team Members

- Author of the paper
- Transportation office
- Inpatient and Outpatient services' secretarians

Figure 1: Project charter

As one of the focus of the whole Lean Six Sigma methodology is to center the analysis on the customer's requirements, his needs regarding how the process should behave and which outputs should produce had to be defined from the start. In this case, the customer is always the patient, and all processes should be designed taking him into account.

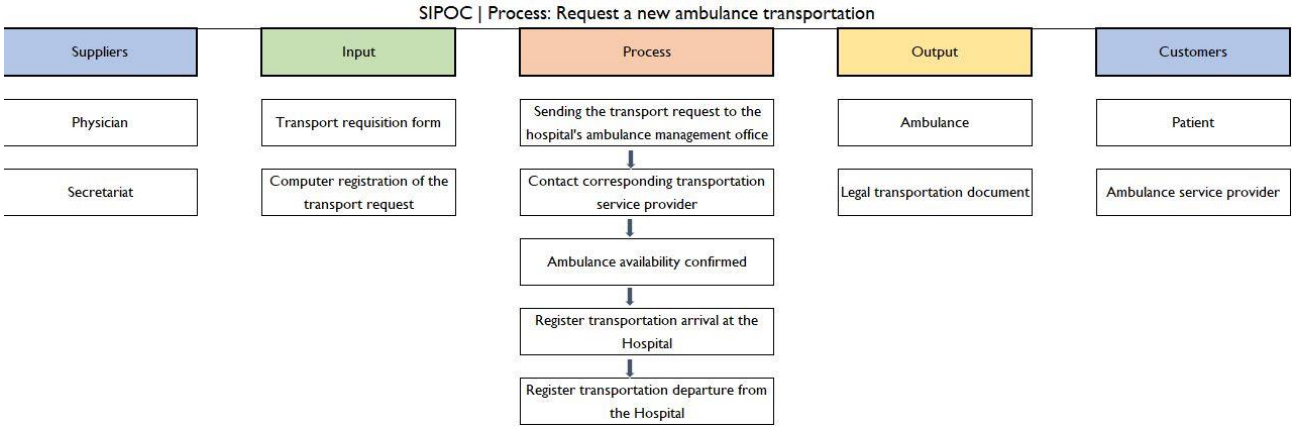

Figure 2: SIPOC map to create a high-level view of the ambulance's request process

The main requirement of the patients was to have the needed transportation on the exact date, at the exact time so that they would never miss an appointment. As most of the patients with access to this kind of service were mostly elders, to provide high-quality service the request's process needed to run smoothly with the greatest effectiveness and without any unnecessary delays.

To understand how the current parties involved in the process viewed the situation, a Voice-of-the-Customer (VOC) matrix was created to collect and prioritize each staff member's opinion regarding the defined problem. This gave the improvement team deep insights from those directly involved with the situations created by a poorly designed procedure. The prioritization was calculated by multiplying 4 different metrics, defined alongside senior management: frequency, impact on quality, level of dissatisfaction, and the level of risk to the customer.

Who?	What are they saying?	Why are they saying it?	What do they want?	Grade
Secretariado	Tratamento da documentação não é eficaz	Muitas vezes documentos são perdidos, esquecidos ou nem entregues na secretaria	Haver preocupação do médico em explicar ao doente o processo de requisição de transportes	28.8
Central de transportes	Folha de requisição dos tranportes é mal preenchida	Não são preenchidos todos os campos necessários; datas incorretas; incoerência com os episódios clínicos	Sejam impostas regras de preenchimento para perderem menos tempo e reduzirem os erros na chamada de transportes	57.6
Coordenador	Central de transportes tem problemas internos de comunicação com os secretariados	Consultas com transportes afetos são remarcados sem a central de transportes ser avisada; não é verificada se há realmente transporte para aquela nova consulta	Estar indicado de alguma forma que aquele paciente tinha um transporte alocado // Criar um mecanismo de segurança para estas coisas (doentes que já se sabe que têm transporte terem um procedimento próprio para estes casos)	51.2
Central de transportes	Médico devia ser responsável por preencher todos os campos clínicos incluindo a justificação	Dá informação importante às cooperativas para prepararem os transportes corretos, de acordo com a condição do paciente	Que sejam impostas regras de preenchimento, para o médico e secretariado ou que tudo seja lançado informaticamente pelo médico	51.2

Figure 3: Voice of the Customer matrix

Using the VOC, the team was capable of further narrowing the analysis from 10 different directions to only 3. These were the basis for the investigation shown in the Measure phase.

Phase 2: Measure

In the Measure phase, both the standard ambulance request's system and the digitalized one were mapped and analyzed to identify the value-adding activities. By defining the steps in the process, which contribute with value to the patient, it is possible to start designing a roadmap to optimize them and reduce or, if possible, eliminate the ones that do not add value to the desired outcome. In the case of the first process, only 75% of the total activities taking place in the process currently implemented for scheduled transport, add value to the patient. On the other hand, only 70% of the total activities taking place on the digital circuit currently implemented for daily transport, add value to the patient.

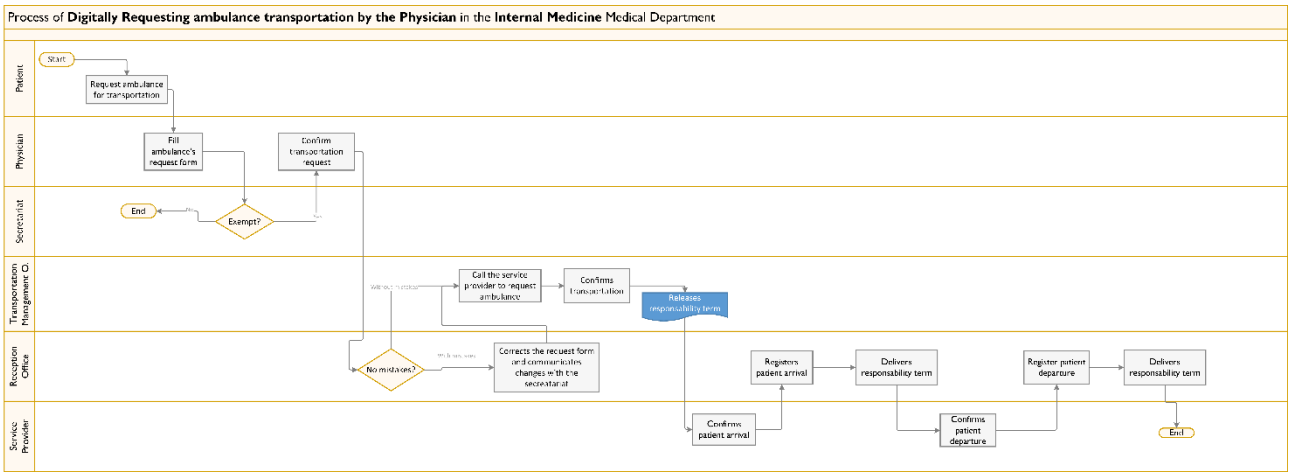

Figure 4: Deployment diagram of the digital request of ambulances

Here, it is presented the deployment diagram for the digital prescription model and the original model used in all other specialties, albeit with constraints. The digitalized process took only 16 steps to achieve the goal of setting up transportation with a company, whereas the other one took 21 activities in total to fulfill the objective, and one more lane (intervenient/resource for the process to be executed). This means that, even with all the inefficiencies present in the digital prescription process, there is already a 24% reduction in the total number of activities/steps needed to perform to complete the procedure. In terms of lead time, the digitalized request system takes less than 9 minutes than the standard procedure, making it a much better choice for the future.

KPIs	Standard Request System	Pilot Project (Digital Prescription)	Advantages of the Digital Model
N° of steps needed	21	16	24% fewer activities
N° of people involved	7	6	15% fewer intervinients
Lead Time (minutes)	32,5	23,5	28% less time needed

Figure 5: Comparison between standard and digitalized request's process

These measurements gave management a better understanding of the advantages of a paperless system, where the physician is the one responsible for filling the digital form and requesting the ambulance for the patient, without needing the involvement of a second party – the secretary of the medical department.

However, as both processes were being mapped through walk-throughs and interviews with personnel, different problems became evident. These are, as follow:

1. The physician is still dependent on the secretary to check if the patient is entitled or not to have transportation financially supported by the Hospital;
2. The responsible for the reception welcoming all patients arriving with ambulances has to check each transport documentation of this type to ensure that they are well done;
3. There is no control over the entry and exit of users. Ambulance staff, which are not working for the Hospital are responsible for confirming and validating these events. This leads to errors in the count of patients and, as a consequence, in the payments to be formalized by the hospital.
4. Lack of a control mechanism for the single-way trips, to check if the patient warned or not that he did not need transport. Many times, in cases where only single-way trips are happening the patient alerts the ambulance's companies that another person will pick them up, and, thus, there is no need for transportation financially supported by the hospital. However, taking advantage of the current system, the companies perform the trip either way, without informing the hospital, and then demand the payment.

Following the identified problems, mentioned above, a root cause analysis was performed and presented in the next stage.

Phase 3: Analyse

Taking into account the multiple disturbances detected when the staff was requesting ambulances, a fishbone diagram was used to categorize problems, and link them with two main issues: unnecessary ambulance requests, and resistance to the transition to a paperless model. From it, 7 root causes were selected as the main drivers of the problems that arise constantly. These problems are:

1. With the digital prescription, nurses no longer had access to the scheduled transport time for the patients they are following, which leaves them a little lost when it comes to preparing patients for departure;
2. The system allows transports to be scheduled when the patient is still hospitalized;
3. There is no guide to assist in filling out ambulance request forms in the IT system;
4. Physicians, now 100% responsible for filling out digital transport order forms, still ask their secretariats for help in many of the requirements;
5. Physicians do not inform changes in medical appointments for patients with a scheduled ambulance, which leads to an unnecessary ambulance trip to pick up a patient with no appointment in the Hospital;

6. There was little involvement of physicians, nurses, and secretariats (the main stakeholders of the process) in the transition to 100% digital requisitions;
7. Lack of feedback meetings throughout the implementation process.

Most of the time, ambulance's proprietary companies are called to do a transport when the patients had their stay in the Hospital extended due to multiple reasons. This situation leads to unnecessary trips for the companies, and payments with no justification for the Hospital, as the patient does not need the requested transport. To tackle this, the Hospital assembled a workstation to verify if each patient needed an ambulance, by calling them one by one (feasible in this case of schedule trips to check if they had already someone to pick them up, and thus no need for transportation by other means or their stay was extended, or appointment rescheduled. However, this station was terminated, because there was the belief it was not changing anything.

To understand the impact of this workstation, and thus, on the Hospital's financials, a Pareto chart was used, to check how many requests were canceled, due to the work described above, and the main reasons for cancellation. By knowing the reasons for cancellation, more granular improvement measures could be recommended to the management team.

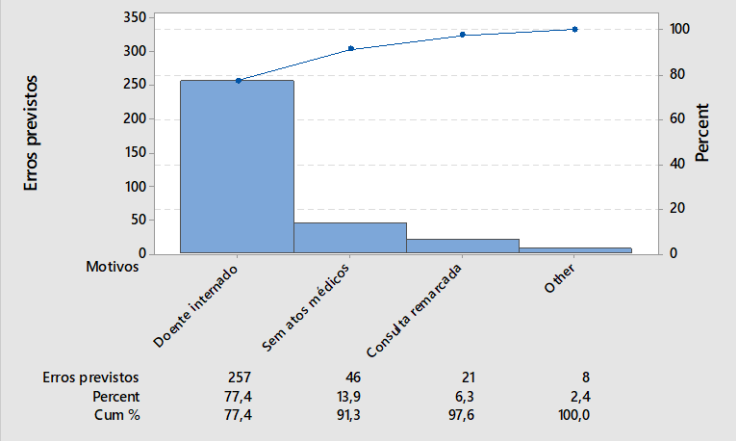

Figure 6: Pareto Chart on the reason for the cancellation of ambulance requests

As seen in the image above, 80% of all the cancellations result from the situation of a patient still being in the Hospital, and almost 10% resulting from cases where there was not any medical act scheduled for the day of the transport. The problems of internal communication – staff from the medical department or even the software used to manage information not alerting the transport's team that a patient with medical acts is still undertaking exams, and thus does not need the scheduled transportation, or, ultimately, needs it to be rescheduled, costs around 10 000 euros to Hospital annually.

In the case of the single-trips that are executed by the ambulance's companies, without a confirmation that the patient is indeed transported costs to the Hospital (in the cases where the transport is issued, and the payment is demanded by the companies) around 40 monetary units. As said previously, these are driven by a lack of control of which patients arrive or depart from/to the Hospital. This information is given by the ambulance's staff, which are not employees from the Hospital. Also, there were some cases detected were the companies went directly to the hospital, stating that the patient was not home, but in fact, the patient communicated that did not need transport, so the Hospital should be informed and cancel the payment.

Calculations lead the author of the paper to predict savings of around 70 monetary units, and less 95 ambulances requested within a year.

Phase 4: Improve

Considering the latter stages, an improved process was proposed as follows:

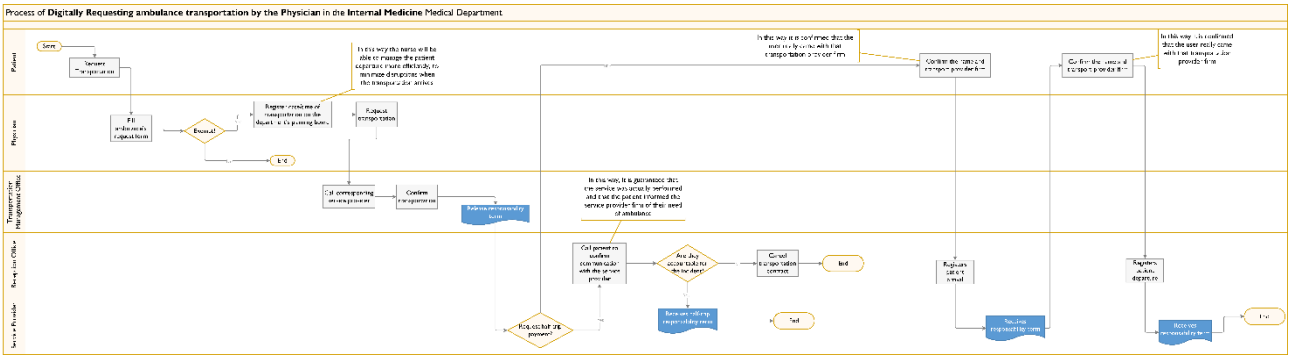

Figure 7: Deployment Diagram of the improved process flow

1. The physician is responsible for placing the date and time of transport on the whiteboard of the service so that the nurse and the secretariat have this information always available;
2. A guide with quick questions and answers was built to assist physicians and the secretariats to answer issues about filling the digital request form, and thus minimize errors;
3. When it comes to single-way trips, the transport's reception is responsible for contacting the patient and confirming that the companies went to the home of the patient and that there was communication between both parties;
4. Entrances and departures are given by the patients themselves, indicating the name and carrier with which they came / will go, to prevent cases in which "ghost transports" occur;
5. Formal workstation dedicated every working day to call the scheduled patients 1 day before to confirm the need for transportation.

Applying the proposed improvement measures, it is expected that the quality of operations improves considerably.

KPIs	Digital Transport Request	Improved Digital Prescription process	Winnings
N° of activities	16	14	12,5%
N° de intervinients	6	5	17%
Lead Time	23,5	18	23%

Figure 8: Comparison between current digitalized process and the proposed process

Phase 5: Control

To assure the continuity of the improvement measures proposed in the "*Improve phase*", a control plan was established and presented as follows:

1. Secretariat should be involved in administrative process improvement projects;
2. Weekly meetings should be scheduled to collect feedback and understand the obstacles that have arisen in the implementation of the pilot project;
3. Constant training must be given to the physicians with the goal of mitigating errors regarding the type of ambulance, time and date fulfillment in the transports requisition online form;
4. Training and follow-up should be given to requesting doctors, as a way to reduce resistance to the transition to a paperless requisition model;
5. Create a data culture, so that metrics associated with the quality of processes are constantly collected and analyzed (time is taken, number of steps, number of people involved, constraints, etc.)
6. In the period of transition to the digitalized process, in which transport arrivals and departures are given by the patients themselves, information must be transmitted to patients and carriers consistently and effectively. Carriers should be involved as it is also in their interest to optimize ambulance utilization.

These recommendations have the goal of realigning the parties involved and helping the management team to continue to push digitalization, by monitoring crucial Key Process Indicators used to analyze and compare processes throughout the DMAIC cycle.

CONCLUSIONS

LSS as a concept with its practical application mostly in the form of DMAIC in improving administrative processes in both manufacturing and service companies has been already in use for several years. Still, it can be said that the application of the Six Sigma-driven thinking in healthcare-related processes is still to be mainstream in management practices, because of the difficulty to implement and control improvement measures, and every successful use case provides another important example to build on existing knowledge. Successful execution of simple projects in hospitals can enable practitioners to tackle tougher initiatives in the future and create clinical/non-clinical process transformations on a broader scale.

Achieving Six Sigma level in operations requires organizations to have a macro and micro understanding of their operations, the underlying drivers for processes variability, and the effective and continuous assessment of their costs. The operationalization of such initiatives following a logical structure such as the one provided by DMAIC can increase the effectiveness while allowing an adequate and proactive answer to expected roadblocks in every transformational project. Appropriately implemented, it produces benefits in terms of better operational efficiency, cost-effectiveness, and drive higher process quality, which then translates in greater profit and higher customer satisfaction. Also, it has the potential of driving improvement in a set of different verticals within a Healthcare provider, such as infection control, surgery room turnover, or access to clinical information.

In the exposed case study, the proposed solutions may bring many different benefits not only for the Hospital, but also for the patients it serves, and the employees involved in the ambulance request system. The benefits of this implementation can be as follows:

- *Hospital* – savings of around 70 monetary units, with the mitigation of unnecessary requests of ambulances and correcting transportation requests related to single-way trips;
- *Patients* – Increased customer satisfaction, as they receive their transport when they need it, at the right time, with the right characteristics;
- *Employees* – Less time focusing on correcting incorrect ambulance requests. Time saved in reworking is time utilized for the effective execution of activities and services, which is added to productivity.

As presented, it can be used to analyze the impact of the digitalization of specific business processes building a benchmark with the original manual operations, while still looking for ways to reduce the friction in the new one. For the ambulance's request system, a new digitalized process was proposed with an expected reduction of 23% in terms of lead time since the moment the need for a transport

triggers the request of a new ambulance until the patient arrives or departs from the Hospital. Also, other issues in the process were identified, related to an excessive request of ambulances which represented a significant overhead cost for the Hospital, for which improvement recommendations were proposed.

As a closing remark, the authors see the need for LSS in the digitalization era, applied in close collaboration with other process improvement tools, such as process mining and other advanced process analytics methodologies, to improve the results of the implementation of new technologies and other data-driven transformations.

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