IMPROVING WORKFLOWS IN A HOSPITAL THROUGH THE APPLICATION OF LEAN THINKING PRINCIPLES AND SIMULATION

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ABSTRACT

This paper focuses on the external consultation and internment services in a hospital from Northern Portugal. The main goal was to improve the patient and hospital technical assistant's flows at these services applying principles of Lean HealthCare, i.e., principles of Lean Thinking adapted to the health care services. Several problems were identified in these services. Examples are deficient information and signage, long queues, lengthy waiting times resulting from various service inefficiencies. In order to solve these problems, some proposals for improvement were made, using Lean tools such as kanban systems or Visual Management and other tools like simulation using Arena software. These proposals may lead to a better management of working time for technical assistants, shorter queues and waiting times, reduced travel for patients and technical assistants by avoiding overlapping of workflows.

Keywords: Lean Thinking, Lean HealthCare, Workflows, Lean tools, Simulation

1 INTRODUCTION

As in many countries, Portugal decided to implement a National Health Service in 1979 with the aim of improving health organization and health care services provided to users. The Portuguese National Health Service (SNS- Serviço Nacional de Saúde) represents a systematic and hierarchical set of institutions and official healthcare providers, operating under the supervision of the Ministry of Health. Following the implementation of the SNS in Portugal, health organizations, over the years, have improved their processes, services, and results in a consistent way. However, because of the increasingly public pressures for better services, all health organizations are constantly seeking to demonstrate better performance and quality [1]. Given the extent and complexity of the work performed in hospitals, it is easy to find overlapping processes, resulting in unnecessary redundancies and wasted resources. One of the services in health organizations where this type of overlap occurs

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frequently is at the secretarial service. This service is composed of two types of activities, involving patients and administrative personnel. The secretarial work is carried out by technical assistants, in different shifts. This is developed in service counters which have allocated one or more technical assistants.

According to Campbell et al. [2], the growth in demand for health services, the increase in costs and restrictions, as well as the constant changes in clinical practices, have increased the interest in monitoring the quality of health services. One of the solutions to deal with these problems is an effective management, which will lead to a constant elimination of waste. This management has gone on to implement Lean Production [2] designated, in the context of health care services, by Lean HealthCare [3].

A hospital in northern Portugal realized this opportunity to make a better use of its resources and proposed a project to improve hospital workflows by applying Lean Thinking principles. The services studied were the secretarial services, namely External Consultation and Internment. The main objectives were to analyze the productive processes of the hospital, related to External Consultation and Internment, identifying workflow overlaps and analyzing user flows aiming to improve performance measures and streamline workflows. Other objectives were to increase service productivity, reducing waste and process costs by shortening the times of various procedures. This project was undertaken under an Action-Research methodology by a master Industrial Engineering student to achieve his dissertation objective.

This article is divided into six sections. After this introduction, a literature review is made in section 2. Section 3 describes the research methodology used. Section 4 contextualize the study, identify the main problems found and present the improvement proposals suggested. These proposals are discussed in section 5 as well the results achieved. Finally, the main conclusions are presented in section 6.

2 LITERATURE REVIEW

In 1988, Krafcik [4] published the article "Triumph of the Lean Production System" as a description of the Toyota Production System, thus disclosing the Lean Production designation for this system. According to Hines [5][6], the designation Lean Production is always evolving, implying that there is no single definition. This may be a good explanation for the divergence of definitions among different authors. At present, there are several Lean definitions, one of which is: "Lean is a customer-focused production organization model that seeks to eliminate waste (activities that do not add value to the product, which the customer is not willing to pay) and the timely delivery of quality products at low cost, respecting people and the environment" [7]. Waste or Muda is any activity that does not represent added value from the customer's point of view. Identification and elimination of waste is critical for any organization. Systematic waste reduction is also a consistent attack on the underlying factors of poor quality and of fundamental management problems [6].

Ohno [8] has identified seven major types of waste from production processes. These wastes can be identified not only in production but also in administrative areas and in other contexts. Several authors, namely Liker [9] also identify an eighth waste, which is untapped human potential. The various types of waste, in a succinct way, can be identified as: 1. Overproduction; 2. Waiting; 3. Movement; 4. Transport; 5. Inventory; 6. Over-processing; 7. Defects.

After the success of the book "The machine that changed the world" by Womack et al. [10] many companies were willing to implement the system that led Toyota to success, and the authors of this book received many requests to guide them in this direction. Thus, Womack and Jones [11] have identified the five fundamental principles of Lean Thinking: 1.Value; 2.Value Stream; 3.Flow; 4.Pull Production; 5. Pursuit Perfection.

In addition to companies in the industrial area, other areas wanted to implement Lean, as was the case in the health area. The Health Lean, or Lean Healthcare, started in 2000 with the goal of improving healthcare. One of the great challenges for Lean Healthcare is to realize in which processes and services Lean tools can be introduced to eliminate waste. This requires the study of workflows in order to get a clear overview of the organization, tasks, and procedures [12]. To do this, there is a need to distinct between activities that add value and those that do not add in order to improve the operational level by eliminating these last activities. Because healthcare resources, directly or indirectly, should be used to benefit patients, the underlying goal of Lean applied to healthcare is to improve value for patients. Doing so will not only benefit the patient, as well as, the people involved in the hospital unit [13][14]. The largest of these benefits will be the elimination of the seven types of wastes associated with hospital facilities.

3 RESEARCH METHODOLOGY

In order to achieve the objectives of the project described in this study, a research methodology appropriate was selected. As the study was carried out in an organization (i.e. hospital) context the Action-Research methodology was considered the most adequate. This methodology, developed by Kurt Lewin, does not have a consensual definition, but can be translated as "learning by doing" [15].

Action-Research works through a cyclical process, done in a conscious and deliberate way. This is characterized by several phases to achieve the desired results for a project: 1) Evaluation of a situation that alerts to change (Diagnosis or defining the problem); 2) Planning of actions; 3) Implementation of actions; 4) Action evaluation, leading to new planning cycles and 5) Specification of learning [16].

4 STUDY CONTEXT, PROBLEMS AND PROPOSALS FOR IMPROVING WORKFLOWS

The project development followed the phases of the Action-Research methodology and in this section the same order is followed to present what was done in each phase, preceded with a brief description of the secretariats organization.

4.1 Characterization and description of secretariats

This project was developed in the External Consultation and Internment service secretariats which are characterized and described in this section. A service secretariat in the Hospital is a place where two types of tasks are performed: services and administrative tasks related, directly or indirectly, with users (patients). In each of these secretariats, one or more technical assistants (TA) work to ensure that a list of tasks, of both types, provided by the Hospital administration, is fulfilled. Most of the time, the TA remain at their service desk, unless they have to assist another service, when requested. Table 1 shows the number of secretariats associated with each service and their location.

Table 1: Number of secretariats per service and their location

Service	Number of secretariats	Location
External Consultation I	3	1 secretariat at floor 1 of building 1 2 secretariats at floor 2 of building 1
External Consultation II	3	1 secretariat at each floor of building 2
External Consultation III	4	1 secretariat at each floor of building 3
Internment	9	1 secretariat at floor 2 of building 1 1 secretariat, at each floor, from floor 4 to 11 of building 1

The hospital of the study has three buildings (1, 2 and 3), in which the three External Consultations and the Internment facilities are located. Building 1 consists of 11 floors, building 2 has two floors

and building 3 has four floors. Each secretariat is associated with specific medical specialties and each service can have more than one secretariat. Concerning users' workflows, the most frequent flows to secretariats are represented by the Spaghetti Diagram of Figure 1, where the user 1 does not need to go to the secretariat at the end of the consultation and the user 2 needs.

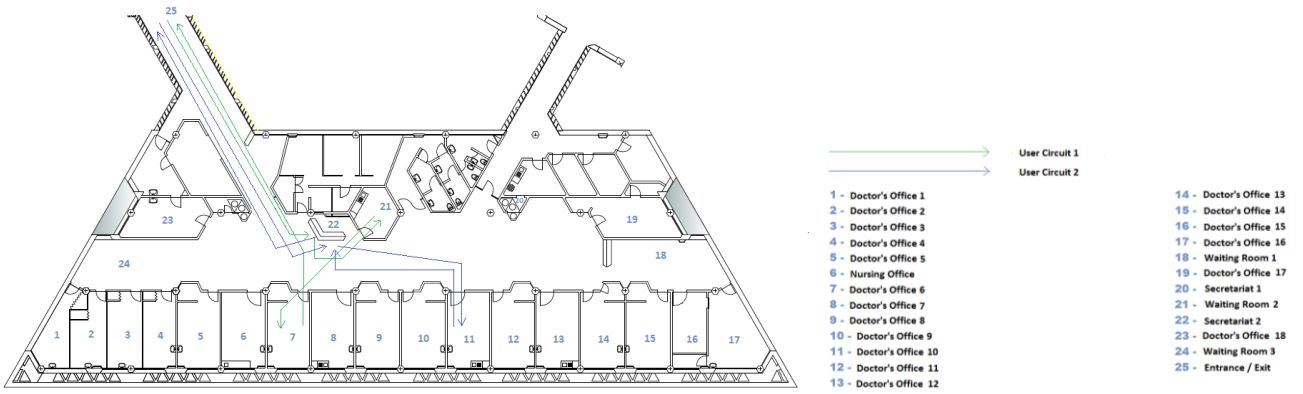


Figure 1: Spaghetti diagram of two possible patient flows in the hospital

Very briefly, user 1 go to the secretariat to confirm the consultation and to pay for any fee or tax fee, if it is not exempt. Then he/she is asked to go to the waiting room until he/she is called by the doctor. Then the doctor calls the patient and performs the consultation. In the end, he/she moves to the exit. For user 2, the circuit is the same until the consultation is done, but if he/she needs something from the secretariat at the end, such as, requesting a presence statement or making a new appointment, he/she must return to the secretariat and only after move to the exit.

4.2 Critical analysis and problems identification

In this section, some of the main problems related to the secretariats of the External Consultations and the Internment are highlighted. These problems were identified using critical analyzes performed through observations and registers and interviews. Also, simulation model in the Arena program with real data, Spaghetti diagrams, activity classification tables were used. Additionally, two surveys were applied, one to users and another to TA at the Hospital to know their difficulties in finding the secretariat wanted and their motion in the hospital. In the case of the TA, the survey also serves to know their satisfaction and difficulties they face when they are working.

4.2.1 High number of wastes in secretariats

During the critical analyses, a lot of problems was identified that had a negative effect on administrative work. The identification and classification of activities performed in the secretariats showed that, in average, 80% were waste (e.g. attend phones calls that were not for secretariat (mistake calls) or medical consultation support). Some of the root causes for these wastes were disorganization in the secretariats, equipment breakdowns and missing administrative material. For example, the lack of administrative material results in a greater difficulty in performing various tasks. Sometimes, TA had to move to other secretariats to borrow material or, for example, to photocopy or make a telephone call. In interviews with several secretaries' technical assistants, it was reported that the Procurement Service, which provides the administrative material, was not warned by the TA who forget to ask for the material they need in a timely manner, by a computer program. Another type of wastes were the excessive use of paper or labels due to mistakes when they are printed.

4.2.2 Waiting times in queue for the secretariats and high service times by TA

When patients need a consultation, an exam or any session in the day hospital, they must carry out the respective document obtained in a specific secretariat. For the External Consultation, with a few exceptions, patients spend a lot of time in the queue, which is caused by the fact that there are many users to be served and the number of TA is small. The average waiting time in different secretariats was studied and it was clear that some secretariats had much more users than others. For some secretariats the average waiting time exceeded 4 hours.

In order to improve and complete the data available, both TA and users were asked, through surveys made at all external consultation secretariats, if they felt that users waited too long in the queue to be served. After analyzing the responses of both, exactly the same conclusion was corroborated: excessive waiting times.

Simulation was also used to validate previous findings and to identify other revealing indicators. The simulation model was developed with the Arena software from Rockwell Automation using data concerning one of the more demanded secretariats, consisting of a service desk with three TA for six specialties. The model is based on the users flow illustrated in Figure 2. It was constructed using actual data taken from observations, records and time-stamping. The first module of Figure 2, from the left, represents the arrival of users. The last two modules represent the transfer to another hospital service or to the exit. The processes concerning floor 2 secretariat, waiting room and consultation were defined using the number of places available in each of these processes, the number of TA and the associated processing times. The first diamond module represents the user decision on whether or not to return to the secretariat, based on proportions estimated from real data. The second diamond module concerns the user decision to leave the hospital or to go to another service. Finally, there is a module to identify users who have been to the secretariat once.

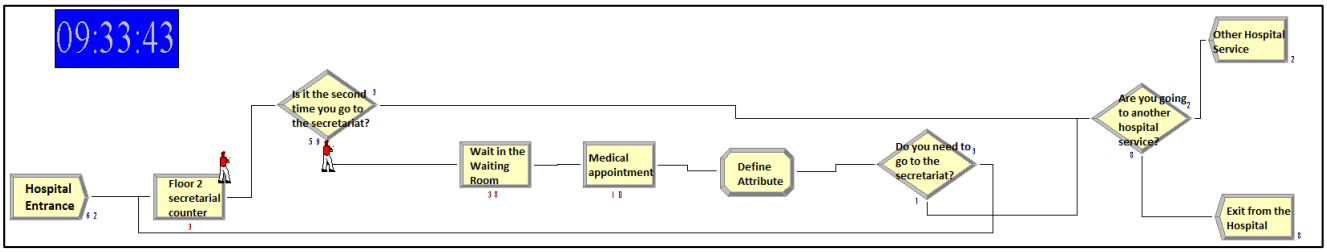


Figure 2: Arena model for users flow on a floor of a given External Consultation

In Table 2, it is possible to see a summary of the results obtained by simulation.

Table 2: Time spent and number of users in the queues of the secretariat

	Secretariat with 3 TAs
Average total time spent in the queue	1h7min
Average number of users in the queue	26 users

TA assured the achievement of all the several activities specified for the secretariat. This may be difficult to accomplish taking into account the time spent attending users. In addition, the number of activities is high and several are time-consuming. Sometimes, attending patients requires all the morning and part of the afternoon, leaving very little time available to perform the other required tasks. Due to this problem, and taking into account the answers to surveys made to the users and TA, it was considered important to measure service times in the secretariats of the External Consultation and Internment, using a chronometer, and to confirm, through data provided by the hospital, the number of users per secretariat. The results showed that, for some secretariats, the average daily service time exceeded six hours, which represented a high time, taking into account the additional

administrative tasks that TA have to perform. The Arena program was also used to identify relevant factors related to this problem. From the simulation, it was concluded that the average total time spent by a user in the secretariats was 2h59min (approximately, 3 hours) and the average number of users in the secretariats was 49 users (WIP).

4.2.3 Communication difficulties with secretariats

Some problems identified were related with contact and communication with secretariats due to the lack of information, unsuitable signaling or appointed exams in different places. Many times, these problems implied users missing scheduled appointments.

Lack of information is observed in many places of the hospital, which causes users to waste time with unnecessary movements. In the case of older patients, this can be considered a serious problem, since they have greater difficulties of locomotion. Additionally, most of the patients who rarely go to the hospital reported that they had difficulties in finding the intended service, and, even, some of the more regular users reported still facing some difficulty. The current signaling does not help because there are situations of improper, missing hided or signaling. The user journey in the hospital does not finish after the consultation because he/she must proceed to schedule next appointment of additional exams. This implies a lot of movements inside or outside the hospital. Due to the lack of information, missing notifications or wrong data (for example, wrong patient address), sometimes patients miss their appointments implying new services for scheduling.

5 IMPROVEMENT PROPOSALS AND RESULTS

In this section, improvement proposals for some of the problems found in the secretariats are studied, namely those mentioned in the previous section. These proposals were analysed using the 5W2H technique, although here in Table 3 just the 2W1H are presented.

Table 3: Improvement proposals

What	Why	How
5S in the secretariats	High number of wastes in secretariats	Lean Thinking principles and tools training to TA, in particular, about 5S, visual management and Kanbans
Phone central		Allocate a TA in a call centre, to direct correctly the phones calls
Maintenance plan for equipment		Build a sheet to register breakdowns occurrences and define a maintenance plan
Kanbans for material requests		Creation of Kanban template to improve the replacement service and a Kanban instruction, explaining the process.
Paper reuse		Make TA aware for the reuse of paper
Tickets service machine	Waiting times in queue and high service times	Invest in a number of tickets machine in each building to make the appointments.
Use of inactive desks		Divide the six specialities of floor 2 by the 3 service desks and divide the number of TA by these instead of being all in the same secretariat
Visual management	Communication difficulties	Put or improve the signalling system with precise information and of easy understanding and allow the exams appointment in any secretariat.

The proposal that could be more costly is the call centre, with an estimated cost of 179.95€ for the equipment and 13683.84€ per year for a TA (if it is necessary to hire one). Nevertheless, the gains obtained with this proposal were estimated in 27187.33€ (assuming that in the secretariats are lost, in average, 19 hours/day attending calls). With the proposal concerning paper reuse, the savings were estimated in 2283.40€ per year.

To estimate the results concerning ticket service machines and the use of inactive desks, it was used Arena simulation software to evaluate different solutions. The current situation required three TA. By increasing incrementally this number until six it was verified that the queues drastically reduced.

But hiring three additional TA would have huge costs, so it was necessary to analyse different solutions. The solution presented underwent a reorganization of this floor using two existent inactive desks. Thus, the six specialties operating at this floor would be distributed by the three secretariats, according to the expected affluence to each specialty. The number of TA would also be allocated to the different secretariats. Following this suggestion, a new model was developed. The improvements that may result from this proposal, in terms of queues, resources and users have been tested in the Arena software. The new Arena model construction is similar to the previous. The number of branches (Branches 1, 2 and 3) and the number of TA were changed accordingly, as can be seen in Figure 3.

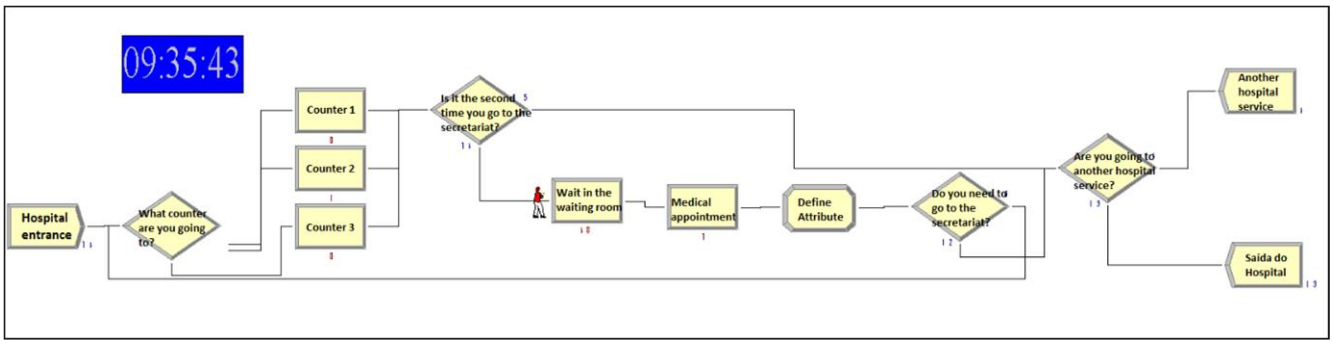


Figure 3: User flow on the floor of the External Consultation proposed by Arena software

In Table 4, it is presented a comparison of two indicators, average total time spent by users and average number of users in the secretariats, for three scenarios: the current state of one secretariat with three TAs, the optimal solution given by Arena with one secretariat with six TAs and the new proposed layout with three secretariats with one TA each.

Table 3: Comparison between three scenarios

	Secretariat with 3TAs	Secretariat with 6TAs	3 secretariat with 1TA
Average total time spent by a user	2h59min	1h23min	1h22min
Average number of users in the secretariats	49	23	22

It can be seen that the average time spent in the system by a user and the WIP in this new solution are much smaller than for the current situation (less than half for both indicators) and slight lower when compared with the ideal solution given by Arena. The queue indicators were also analysed for the three scenarios mentioned above. The results are presented in Table 5. Concerning these indicators, the same conclusions are verified. There is only one exception, the average waiting time in the queue is slightly higher in desk 3 when compared to Arena's ideal solution with six TA. But, this time is compensated with a shorter service time in the other two desks.

Table 4: Comparison between queues times of current situation, ideal solution given by Arena and the improvement proposal

	Secretariat with 3TA	Secretariat with 6TA	3 secretariats with 1TA each		
			Service Desk 1	Service Desk 2	Service Desk 3
Average total queue time for the secretariat	1h7min	51 sec	45 sec	29 sec	1min23sec
Average number of users in the queue for the secretariat	26	0,34 (<1)	0,09 (<1)	0,04 (<1)	0,23 (<1)

Analysing these results, it was concluded that, in some cases, it was not necessary to hire more personnel. The key to explain this difference in results is the better balancing done in the division of specialties by secretariat, reducing waste related to the clutter in the waiting queues. These proposed

changes could facilitate everyone's work and increase productivity. In this case, it was verified that with a small change in the layout of the secretariat and in the work organization the processes could be more productive, not requiring additional resources. In financial terms, this proposal can avoid the costs of hiring three TA. In quantitative terms, this reorganization can reduce waiting times and, consequently, to reduce the time spent in the system by users. Also, TA will have more time available to perform administrative tasks.

6 CONCLUSION

The objective proposed was to improve the workflows in a hospital, applying Lean Thinking principles. For this, a diagnosis was made and a number of problems related to the secretariat service of the External Consultation and the Internment were identified. Some of the problems were: long waiting times in queues, high service times, inadequate signalling and missing administrative material. To address these problems some Lean tools were proposed such as 5S, Kanban systems and Visual Management and other tools like simulation using Arena software. After this project, since the proposals have not yet been implemented, some expected results were estimated based on theoretical calculations using data presented by the hospital or obtained in local. It was confirmed that these proposals could contribute for a better service in both qualitative and financial terms.

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