

Implementation of Lean Healthcare Approaches in a Hospital's Surgical Block

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Abstract: Over the last decades, there has been a growing demand for healthcare services, driven by increased life expectancy, population ageing and the prevalence of chronic diseases. In this context, there is an increasing need to make hospital systems more robust and efficient. To achieve this, hospital managers have increasingly adopted Lean methodologies, focusing primarily on identifying and eliminating waste, making operations and processes more efficient. The application of these methodologies in the healthcare sector is known as Lean Healthcare. Research in this area has gained growing interest since the late 20th century, resulting in a clear enhancement of hospital system sustainability and service quality. However, a significant gap has been identified regarding the observation of processes and the implementation of concrete tools in hospital units, which could directly contribute to the improvement of the healthcare network. This research aimed to diagnose and analyse the current state of the processes and activities associated with the operating room of a hospital unit. It also explored the application of Lean Healthcare tools. The project followed the Action Research methodology, applying a practical and collaborative approach to analyse, identify, suggest and implement process improvements, promoting interdisciplinarity between engineering and hospital operations management. This proximity to a real-world context strengthens scientific knowledge in the field of process standardisation, highlighting Action Research as a valid scientific methodology capable of adding value both to institutions and, simultaneously, to the scientific community. Through the data analysis and *in loco* observation of more than 60 surgeries, it was possible to model preoperative, intraoperative and postoperative processes. This enabled the diagnosis of improvement opportunities. The results revealed that surgeries were frequently delayed due to issues related to medical resource availability. Additionally, operating rooms exhibited low occupancy rates. In response, the research team proposed revised scheduling strategies, implemented 5S audits, process standardization, control checklists and Single-Minute Exchange of Die (SMED) practices. These interventions led to a reduction in non-conformities and errors, including a decrease of over 40 percentage points in non-conformities related to the availability of medical devices. Although there is still a long way to go in Lean Healthcare research, this investigation contributes to a more efficient and robust healthcare network, implementing Lean Healthcare in the surgery department to deliver safer and higher-quality services with the patient at the centre of continuous improvement efforts.

Keywords: Operating room, Hospital operations management, Lean healthcare, Process mapping, Continuous improvement

1. Introduction

Healthcare systems in developed countries are currently facing the challenge of adapting to shifting social structures caused by the inversion of the demographic pyramid, increased life expectancy, the rise in chronic diseases, and the universalization of healthcare services (Jones and Dolsten, 2024). These factors emphasize the urgent need for transformation within the healthcare sector. This transformation partially depends on the adoption of methodologies that ensure greater system sustainability while simultaneously promoting the delivery of higher-quality care to patients.

Portugal's National Health Service (Serviço Nacional de Saúde – SNS) was established in 1979 and is defined as a “universal and centralized system, coexisting with other complementary health subsystems” (OECD/European Observatory on Health Systems and Policies, 2023).

In this structure, the private sector plays a complementary role. The expansion of this Hospitals is largely driven by the demand for faster service in response to limitations within the SNS, including long waiting times and limited access to medical specialties (Mateus et al., 2017). As a result, improving internal processes has become a strategic priority for ensuring the sustainability and competitiveness of private hospitals.

Operating rooms (ORs) often represent the main revenue source in private hospitals (Gupta et al., 2022). Thus, their correct and efficient use is essential—not only to improve the quality of care provided but also to promote the financial stability of the organization.

It is therefore imperative to increase system availability, which requires implementing effective management processes focused on improving efficiency and productivity (Spearman, 2014). To this end, enhancing surgical room productivity is essential for ensuring more efficient patient access, reducing response times between procedures and minimizing idle non-operative time (Gupta et al., 2022). Promoting a culture of continuous improvement and operations management before, during, and after each surgical intervention is thus a key priority (Lima et al., 2021).

In this context, it is important to understand the specific characteristics and complexities of the operating room environment.

The operating room is a production-like structure with a linear flow typically comprising preoperative, operative, and postoperative stages. Its capacity is constrained by the number of available surgical rooms, equipment, human resources, and various technical and administrative delays, among other factors (Cima et al., 2011).

Operating rooms are defined as “organic and functional units composed of an integrated set of physical, human, and technical resources, designed for scheduled and emergency surgical interventions, diagnostic exams and other invasive procedures that require a high level of asepsis and/or anaesthesia control for the patient, with the goal of restoring or maintaining their health” (Ministério da Saúde, 2015).

From an infrastructure standpoint, the operating room comprises surgical suites where procedures are performed and is part of a broader surgical unit that includes disinfection areas and support rooms (Terras, 2017). These rooms accommodate scheduled (ambulatory), unscheduled and emergency surgeries, which may or may not require subsequent hospitalization (Pereira, 2014).

Surgical services involve multidisciplinary teams and various hospital departments (Pereira, 2014). Operating rooms hold significant strategic importance for hospitals, as they represent high investment and operational costs, due to the constant need for technological innovation and highly specialized human resources (Pereira, 2014). It is therefore essential to maximize the use of installed capacity and the resources available in these units.

Addressing some of these challenges can be achieved through the application of tools aimed at increasing productivity by eliminating waste and implementing operational management techniques that improve efficiency (Souza et al., 2020). While these tools originate in industrial settings, they can be successfully adapted to healthcare management, particularly in surgical environments.

The term “lean” was originally coined to describe a system capable of delivering outcomes using the fewest possible resources—whether physical space, labor effort, capital investment, or inventory—while also generating fewer defects and safety incidents. Over the decades, it has evolved into a methodology associated with achieving more efficient results. Several authors highlight that the primary goal of Lean in organizations is to improve process flow by reducing waste, non-value-added work, and cycle time (Lima et al., 2021).

Lean production systems represent a set of strategic goals and principles unique to each organization, employing operational methods and tools for a holistic approach to process management (Schumacher, Bildstein and Bauernhansl, 2020). Their general structure comprises objectives, processes, principles, methods and tools tailored to the specific needs of each organization.

The concept of “Lean Production” originates from the Toyota Production System, developed by Toyota Motor Corporation and adopted by many Japanese companies in the aftermath of the 1973 oil crisis, itself a consequence of World War II (Monden, 2012). At the time, resource scarcity prompted a strong focus on eliminating all non-essential processes in factories through a problem-solving approach designed to identify causes and develop resolution methods (Monden, 2012).

Womack, Jones, and Roos (1990) were among the first authors to reference the use of Lean techniques in service contexts, particularly healthcare delivery. They argued that the first step toward proper Lean implementation in healthcare involved placing the patient at the centre and considering time and comfort as key performance indicators. These authors emphasized the importance of versatile care teams and active patient involvement as essential components of Lean methodology in healthcare (Poksinska, 2010).

The term Lean encompasses a set of tools, a management system, and a philosophy capable of transforming the way hospitals are organized and operated. When applied to the healthcare sector, the term becomes Lean Healthcare. This methodology enables hospitals to improve the quality of patient care by reducing errors and wait times, ultimately resulting in lower operational costs. Moreover, it helps dismantle silos between disconnected departments, allowing them to collaborate more effectively for the benefit of patients (Graban, 2016). Research in this field has significantly advanced over recent decades, confirming Lean Healthcare as both an innovative and effective approach.

This study aimed to standardize and improve the processes associated with a surgical block of a Portuguese hospital through the application of Lean Healthcare principles. The first objective was to diagnose and analyse the current state of processes related to the operating room, and to enhance these activities using Lean Healthcare methodologies. The final goal was to increase operational efficiency, reduce waste, improve service quality and, consequently, patient satisfaction.

2. Methodology

To achieve these objectives, an Action Research methodology was adopted. This approach allows not only for the understanding, improvement and reform of practices but also for the execution of interventions in real-world organizational settings, with detailed analysis of the resulting effects.

This methodology is defined as “a family of research methodologies which combine action (or change) with research (or understanding) in a cyclical or spiral process that alternates between action and critical reflection” (Coutinho et al., 2009). The present study was designed to be participatory and collaborative, involving all stakeholders in the process—including researchers, nurses, healthcare assistants, physicians and administrators. The research also aimed to be practical and interventionist, going beyond theory to implement real-world changes (Coutinho Pereira, 2006). It followed a cyclical process in which early findings informed potential changes, which were then implemented and evaluated (Cortês, 1998). The project also involved critique, as participants were not only seeking improved practices but acting as agents of change (Zuber-Skerritt, 1992). Finally, the research was self-evaluative, with all implemented changes being continuously assessed to develop new knowledge (Coutinho et al., 2009).

The model was structured in five stages (Table 1), which were applied as follows:

Table 1: The five stages of the Action Research model.

Stage	Description
Diagnosis	On-site observation and process mapping (including patient admission, pre-operative, surgical, post-operative and recovery phases), 5S audit and identification of non-conformities. Surgical time data provided by the hospital were also analysed;
Action Planning	Design of action plans for process improvement, with a focus on standardizing operations and reducing non-conformities;
Implementation	Execution of the action plans through targeted activities aimed at addressing the hospital's specific operational needs;
Results Evaluation	Analysis of the impact of implemented improvements, measuring the extent to which project objectives were achieved;
Learning Specification	Synthesis of conclusions and identification of limiting factors encountered during the research process.

In summary, this methodology allowed the implemented changes to align closely with the organization's strategic goals, fostering and instilling a continuous improvement philosophy—an essential mindset for the ongoing development and progress of the institution.

3. Diagnosis

The hospital under analysis is staffed by experienced professionals and is part of a prominent private healthcare group in Portugal. This group operates nationwide and employs several thousand healthcare professionals. The hospital provides care in more than 40 different medical specialties, both surgical and non-surgical. Figure 1 shows a comparison between the surgeries performed in the hospital's operating room in 2023 and 2024

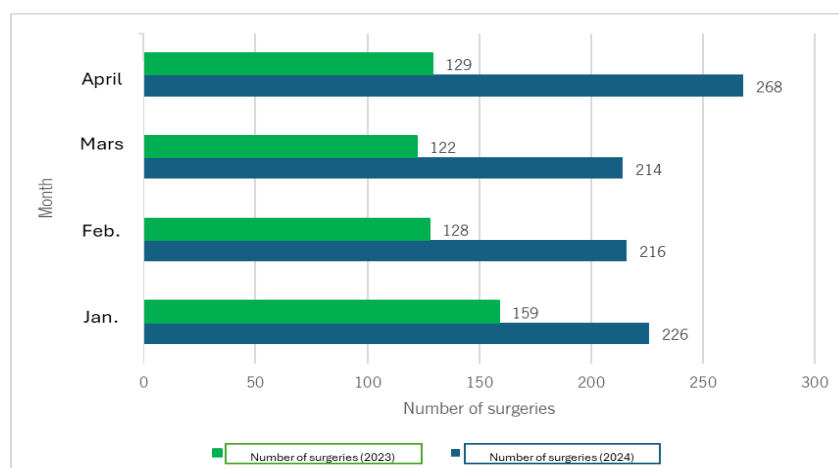


Figure 1: Comparison between the surgeries performed in the hospital's operating room in 2023 and 2024.
(Source: Data collected by the authors)

Reflecting the increasing pressure faced by the Portuguese healthcare system in recent years, Figure 1 shows that in 2024, compared to 2023, the number of surgeries in this hospital increased by an average of 71.7%. This is a highly significant and impactful rise for the institution, with direct consequences for the hospital's internal organization, logistics, and clinical operations.

There is a general perception that, according to Bandi & Gupta (2018), the surgical scheduling process is subject to numerous challenges, such as variability in procedure durations, resource availability (including equipment, staff, and surgical rooms), last-minute cancellations, emergency situations, and the need to maximize the operations room utilization without compromising patient safety or care quality (Bandi & Gupta, 2018).

This increase in demand led to a need for additional human resources and a focused effort to improve service quality, thereby ensuring the continued and sustainable growth of the organization. This is essential to ensure that the service provided does not deteriorate, despite emerging challenges.

To gain an accurate understanding of the hospital's operational reality, continuous on-site observation was conducted, closely monitoring processes. This enabled a precise diagnostic assessment of the hospital's actual condition. Simultaneously, the observation, alongside the analysed data, strengthened an understanding of the existing improvement opportunities within the system. Only through consistent, attentive, and direct engagement with daily activities was it possible to obtain a comprehensive understanding of the system's operations.

3.1 Average Start Time of the First Surgery

Among the various challenges identified, the delay of the first surgery stood out as particularly significant, as it greatly affects the productivity of the operating theatre, leading to a clear waste of human and material resources, including physical facilities. To analyse the delay in daily surgery start times, all surgeries performed at the start of the day between January and April 2024 were recorded. The monthly average start time for the first four months of the year is illustrated in the line graph in Figure 2.

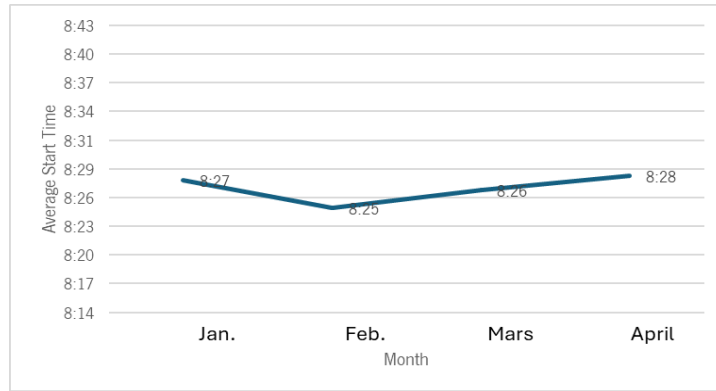


Figure 2: Monthly average start time of surgeries in the first four months of 2024. (Source: Data collected by the authors)

Between January and April 2024, the average starting time was 08:27 AM, which is significantly later than the scheduled start time of 08:00 AM. This delay directly impacts the overall efficiency of the day’s surgical schedule, as the initial delay tends to cascade into subsequent surgeries. However, the delay remained consistent across months, with a variance of only 3 minutes and 12 seconds.

3.2 Operating Room Occupancy Rate

The operating room occupancy rate (Formula 1) reflects the proportion of time the OR is used for its primary purpose—performing surgeries—out of the total time it is available (Formula 2). The available time in minutes (per month) is calculated by multiplying the 11 hours of daily service available by the number of working days in the month, then by 60 minutes, and finally by the two available operating rooms. Cleaning and preparation times are excluded from this calculation, allowing for a true representation of how much time is devoted to value-adding surgical activity. The term 'Value-adding surgical activity' refers to all services that improve the patient's health condition.

$$\text{Occupancy Rate} = \% \frac{\text{used time}}{\text{available time}} \quad (1)$$

Formula 1: Formula for calculating the occupancy rate

$$\text{Available Time} = 11 \text{ hours} * \text{number of days worked per month} * 60 \text{ minutes} * 2 \text{ Ors} \quad (2)$$

Formula 2: Formula for calculating the OR available time

Since the OR occupancy rate (Figure 3) is a structural indicator, improving it depends on minimizing time waste associated with surgical procedures—namely the time taken to start surgeries and the turnover time between them. It is important to note that reducing these times is not merely about cutting idle periods but about making processes more efficient and leaner, while strictly adhering to patient safety and quality standards.

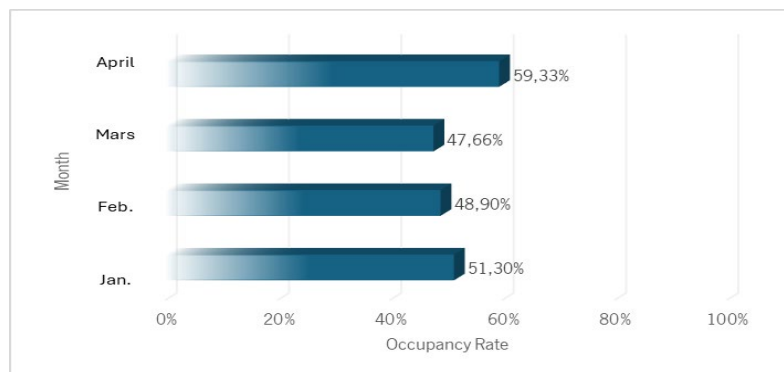


Figure 3: OR occupancy rate between January and April (2024)

3.3 Adherence Rate to the Scheduled Time

The Adherence Rate to the Scheduled Time (Formula 3) indicates the percentage of surgical procedures that actually begin at or before their scheduled start time, as agreed upon by the hospital with healthcare professionals and patients.

$$\text{Adherence Rate to the Scheduled Time} = \% \frac{\text{number of surgeries performed at the scheduled time}}{\text{number of surgeries performed for each time slot}} \quad (3)$$

Formula 3: Formula for calculating the adherence rate to the scheduled time

Between January and the end of April 2024, a total of 924 surgeries were performed, of which only 305 began at the scheduled time. This results in an average adherence rate of 33.01%, which is significantly lower than the hospital’s target, reflecting persistent delays in surgical start times—as illustrated in Figure 4.

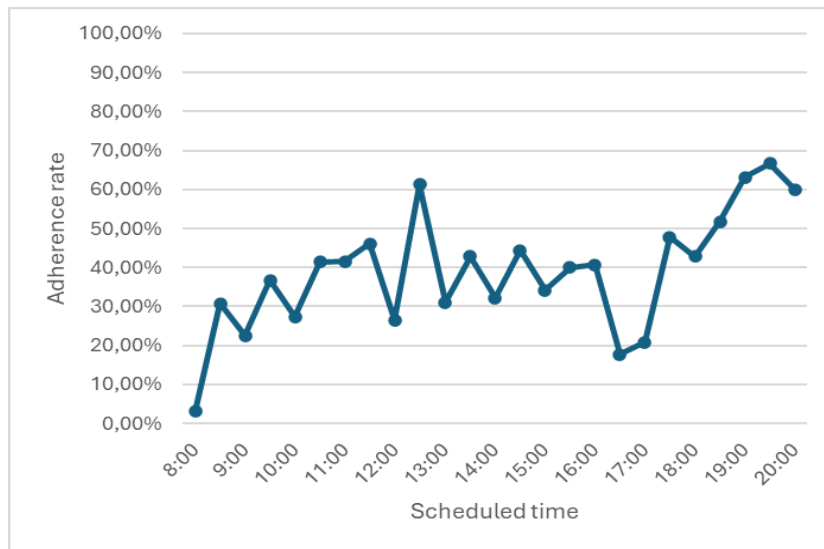


Figure 4: Adherence rate to the scheduled time between January and April 2024 for each time slot (Source: Data collected by the authors)

After analysing the scheduled time slots, the highest adherence rate was observed at 19:30 (66.67%), while the lowest was at 08:00 (3.10%). The low adherence at 08:00 can be explained by the fact that it coincides with the start of the medical team’s shift - with the natural constraints associated - making delays inevitable and directly impacting both the start of the first surgery and adherence to the planned schedule.

It is important to note that several preparatory steps must be completed once the patient enters the operating room, such as the Safe Surgery Checklist and the induction of anaesthesia. Therefore, the actual surgery rarely begins upon patient entry, but instead, on average, starts approximately 14 minutes later.

Moreover, after each procedure, there are additional steps that may delay the next surgery, such as the cleaning and resetting of the room with the required devices and instruments.

3.4 Turnover Time

The Turnover Time (Formula 4) refers to the interval between the end of one surgery and the start of the next. This period is used for cleaning and disinfecting the surgical room, and—when multiple surgeries are scheduled—for preparing all the necessary materials (consumables, medical devices, and equipment). It also includes positioning the room according to the procedure to be performed, including the patient’s orientation (e.g., side of the body to be operated on).

$$\text{Turnover Time} = (\text{Room exit} - \text{end of surgery}) + \text{cleaning time} \quad (4)$$

Formula 4: Formula for calculating the turnover time

Approximately 107 observations were analysed. Figure 5 presents the results of the turnover time analysis, revealing a wide variability in these times, highlighting a lack of standardisation in the process.

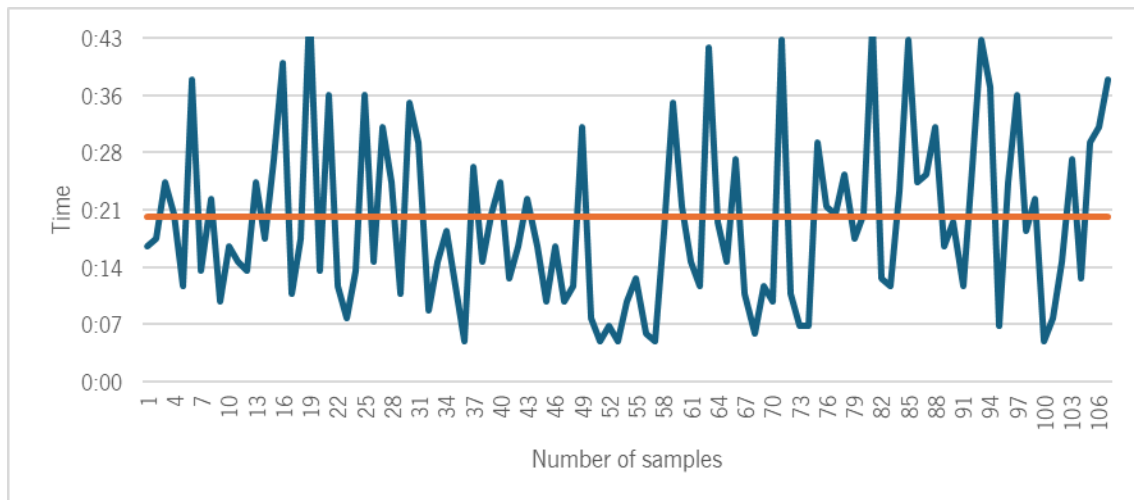


Figure 5: Turnover time analysis (Source: Data collected by the authors)

Following the implementation of cleaning time tracking and data collection related to surgeries, it was found that the average turnover time was 19.45 minutes, with a standard deviation of 11.35 minutes. Simultaneously:

- The average cleaning time was 13.24 minutes, with a standard deviation of 12.17 minutes;
- The average idle time between the end of surgery and the start of cleaning was 6.51 minutes, with a standard deviation of 7.15 minutes.

3.5 Nonconformities and Difficulties Identified

On-site observation during surgical activity revealed that materials used during operations were often poorly labelled, requiring nurses to leave the OR mid-surgery to locate identification tags.

It was also common practice for nurses to check that all required materials were in the anaesthesia cart, within expiration dates, and to verify the functionality of all critical medical devices, including ventilators and patient monitoring equipment.

During the observation period, it was also found that there was no standardized procedure for verifying the contents of the anaesthesia cart. No verification logs were maintained, nor were there defined methods for restocking, revealing a failure in the process.

Furthermore, it was frequently observed that expired consumables were present in the anaesthesia cart. Although nurses always check expiration dates before administering any item, the presence of expired products significantly increases the risk of incorrect administration, posing a potential threat to patient safety.

It is important to note that each surgical procedure involves its own specific consumables, equipment and workflows. Each device must be correctly positioned based on the surgical suite, patient position and operative side, making the most efficient use of the available time.

In addition to basic materials, certain consumables or machines are specifically requested by the surgeon. For the OR to be ready, it must be both disinfected and fully aligned with these specific requirements.

The medical device storage room houses equipment is available to various specialties, including positioning systems and anaesthesia devices. Over time, the organization of this space had been neglected, resulting in a cluttered environment without any logistics standards—no designated areas, insufficient space and no inventory or labelling of equipment.

4. Results and Discussion

One of the biggest challenges in the operating room was the frequent non-conformities associated with the disorganization of medical devices and consumables during surgeries. Often, devices were unavailable when needed or were improperly positioned for immediate use in specific procedures.

According to the non-conformities analysis, most issues were due to missing or mispositioned devices, or a general lack of knowledge regarding device placement. These difficulties stemmed from varying levels of

experience among staff and a lack of consistent knowledge and standard procedures related to medical devices used in the OR. This lack of standardization directly impacted turnover time.

Workplace organization is a key factor in achieving efficient and productive activity. Since the disorganization of the storage room was hindering OR staff performance and increasing turnover time, an audit and intervention were conducted based on the 5S principles (Sort, Set in Order, Shine, Standardize, Sustain). This process involved organizing and identifying all medical devices in storage, making them easily accessible to staff, reducing search time and standardizing organizational procedures across both the operating room and the storage area.

The intervention began by removing all equipment from the storage room and separating it into two groups: devices needed within the OR and those that were not. The second group was moved to an external location. An inventory of all remaining devices was then carried out, including quantities. After placing the devices in their designated spots, all items were clearly labelled. Sterilization-compatible tags were applied to the equipment itself. Additionally, labels identifying the medical specialty associated with each device were placed to further simplify location.

Finally, training sessions were conducted for all relevant staff to emphasize the importance of maintaining consistent organization—not only for operational efficiency but also to enhance the quality, speed and safety of care delivery. Careful and rigorous management of space is essential to avoid chaotic scenarios and potential failures.

Since turnover time is related to the changeover between procedures, it can be considered a form of setup time. As such, it was improved using SMED (Single-Minute Exchange of Die) tools. To support this, surgical setup cards were developed. These cards listed the names of required medical devices on one side and their appropriate placement in the OR based on the type of surgery on the other. This effort helped standardize equipment layout, making the process faster and safer.

To develop these cards, information from an existing manual and input from the nursing team were used. Each day, the cards for the scheduled procedures are displayed by the nursing staff. As each surgery concludes, its respective card is removed and stored in a designated location.

The implementation of 5S principles began with efforts to organize the remaining devices with clear and accessible placement, facilitating workflow. An inventory was created listing all devices and quantities, along with the identification of their designated storage locations, using standards easily understood by all staff.

Healthcare professionals were trained and sensitized to the importance of maintaining a Lean culture and a continuous improvement perspective. The implementation of these changes not only improved the motivation of support staff and the standardization of their tasks but also contributed significantly to reducing non-conformities in the OR, as we can see in Figure 6.

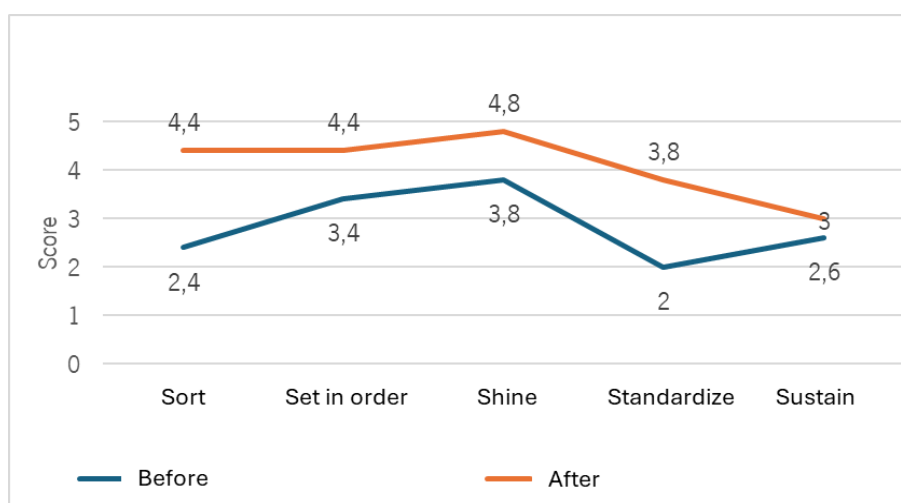


Figure 6: 5S audit results before and after the intervention. (Source: Data collected by the authors)

A 5S audit conducted before and after the intervention confirmed that the reorganization of the storage area led to a positive shift in results: the general audit score rose from an average of 2.84 to 4.08 points, representing a significant increase of 1.24 points.

The work carried out resulted in the standardization of several processes, which made the unit safer and enabled the provision of higher-quality care to patients.

On-site monitoring of surgical operations also made it possible to quantify the causes of non-conformities before and after the intervention (Table 2).

Table 2: Analysis of the root causes of nonconformities before and after intervention. (Source: Data collected by the authors)

	Initial Evaluation	Evaluation After OR Storage Reorganization and Card Implementation	Difference (percentage points)
	%NC	%NC	
Does the professionals know which medical devices are needed?	38%	10%	-28
<i>At the beginning of the surgery/setup, were all medical devices available?</i>	58%	8%	- 50
<i>Do the professionals correctly position the medical devices in the OR?</i>	46%	2%	- 44

The results showed a clearly positive impact on the surgical unit's performance, especially in eliminating previously identified non-conformities. There was a 50 and 44 percentage point reduction in non-conformities related to the availability and correct positioning of medical devices at the start of surgeries, respectively.

5. Final Considerations

This study aimed to demonstrate that the application of Lean methodologies to the hospital context—Lean Healthcare—can promote a more efficient and cost-effective healthcare system. At the same time, it sought to raise awareness among healthcare professionals of the need for a continuous improvement mindset, placing the patient at the centre of the system to enhance the quality of care delivered. The actions implemented during this investigation strengthened the hospital system without compromising service standards. It was also highlighted that the monitoring and standardisation of processes play a central role in system management, contributing to its enhancement and efficiency. This research helped to provide empirical validation of this knowledge, revealing the standardisation of spaces and processes a practical way to make operations leaner.

However, several challenges remain, such as persistent resistance to change and the need to implement continuous improvement strategies in the hospital management system. Although Lean Healthcare tools have seen increasing adoption in recent decades, there is still a long way to go before they can be broadly and systematically implemented throughout hospital systems.

In conclusion, the implementation of Lean Healthcare tools proved to be an effective approach to improving the operation of the surgical unit. It enabled low-cost, quick-to-implement changes that yielded significant benefits for both the organization and its patients.

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Ethics declaration: Ethical approval was not required for this research, as no patient data were used—only information related to workflows and operations. Throughout the study, all ethical guidelines and good practice principles were followed.

AI declaration: No AI tools were used to generate content for this paper. The use of artificial intelligence was limited to supporting translation and checking for potential writing inconsistencies. After using AI, a thorough review of the content was always conducted to ensure compliance. All guidelines and best practices were followed.

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