Surgical patient flow optimization in a public cancer care Hospital

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Abstract

Worldwide, Healthcare Institutions are confronted with increasing costs, ageing populations, capacity issues and resource scarcity in the midst of the recovery of the COVID-19 pandemic. Portugal is no exception as the pandemic severely affected the National Health System, which offers coverage to the entire population. In this context, the increase in new cancer cases, places the Instituto Português de Oncologia do Porto Francisco Gentil (IPO FG Porto), one of the major Portuguese cancer care institutions, at a particularly sensitive position.

This project targeted the optimization of the surgical patient flow at the IPO FG Porto with special focus on creating value for patients and eliminating waste while implementing a culture of continuous improvement, through a set of Lean and Kaizen methodologies.

Resorting to the Value Stream Mapping (VSM) tool the initial surgical patient flow was mapped from the First Surgical Appointment until Clinical discharge. Improvement opportunities were registered and the designed solutions were the starting point for the implementation project. The implemented initiatives were divided between the two macro stages of the process and proved their success by improving the project's key performance indicators (KPIs). In the First Appointment and Planning stage the number of incomplete patient studies that arrived at the Anesthesia Appointment decreased, from 28% to 21%, through the redesign of the patient flow and the implementation of check points. In the Check-in, Hospitalization and Surgery stage, due to the application of Daily Kaizen and SMED, the Operating Room's (OR) starting time was anticipated in 10 minutes and the turnover time between surgeries also reduced - 3.5 minutes. In order to measure the OR's efficiency as a resource, the Overall Equipment Effectivness, OEE, was adapted to the surgical oncology context and after the implementation of the improvement initiatives the OEE increased, from 66% to 72%. The project also resulted in extra 2.8 hours/day for Anesthesia and Surgery. When benchmarking the institution against its Industry peers, in terms of operational KPIs, the improvements were even more clear.

Healthcare Institutions are very complex environments, which may pose a challenge when addressing the implementation of Lean tools. This dissertation intends to depict the application of Lean in the Healthcare sector, namely in the cancer care field, proving once more that Lean isn't an Industry-exclusive concept. Lean Healthcare is possible and proven to be effective and this work intends to inspire other Portuguese Healthcare Institutions to pursue Lean solutions.

Keywords: Lean, Lean Healthcare, Cancer care, Daily Kaizen, SMED, Benchmarking, Overall Equipment Effectiveness, Surgical patient flow, Operating Room

Resumo

Otimização do fluxo do doente cirúrgico num hospital público oncológico

Por todo o mundo, Instituições de Saúde são confrontadas com o aumento de custos, populações envelhecidas, problemas de capacidade e escassez de recursos enquanto recuperam da pandemia de COVID-19. Portugal não é exceção, tendo em conta que a pandemia afetou severamente o Serviço Nacional de Saúde, que oferece cuidados a toda a população. Acompanhando este contexto, com o aumento do número de novos casos de cancro, o Instituto Português de Oncologia Francisco Gentil do Porto, está posicionado numa situação particulamente sensível.

Este projeto, teve como objetivo a otimização do fluxo do doente cirúrgico no IPO FG Porto com especial foco na criação de valor para os doentes, eliminando o desperdício e implementando uma cultura de melhoria contínua através de metodologias *Lean* e *Kaizen*.

Recorrendo à ferramenta de *Value Stream Mapping* (VSM) o estado inicial do fluxo do doente cirúrgico foi mapeado desde a Primeira Consulta Cirúrgica até à Cirúrgia e à Alta Clínica. As oportunidades de melhoria foram registadas e as soluções desenhadas foram o ponto de partida para o projeto de implementação. As iniciativas implementadas dividiram-se pelas duas grandes fases do fluxo do doente e provaram o seu sucesso através da melhoria dos indicadores do projeto. Na fase de Primeira Consulta Cirúrgica e Planeamento os número de doentes que chegava à Consulta de Anestesia sem o estudo completo reduziu de 28% para 21%, através do redesenho do fluxo do doente e da implementação de *check points*. Na fase de *Check-in*, Internamento e Cirúrgia, com a aplicação do *Kaizen* Diário e do SMED, a hora de arranque do Bloco Operatório antecipou em 10 minutos e o tempo de troca entre cirurgias também diminuiu - 3,5 minutos. Com o objetivo de medir a eficiência do bloco como um recurso, o *Overall Equipment Effectiveness*, OEE, foi adaptado ao contexto da oncologia cirúrgica e após a implementação das iniciativas de melhoria, o OEE aumentou, de 66% para 72%. O projeto resultou ainda num aumento de 2,8 horas diárias de tempo dedicado a Anestesia e Cirurgia. Ao fazer *benchmarking* da instituição em comparação com os seus pares da Indústria da Saúde, as melhorias tornam-se ainda mais evidentes.

Instituições de saúde são ambientes complexos, constituindo um desafio à implementação *Lean*. Esta dissertação pretende ilustrar a aplicação de *Lean* no setor da oncologia, provando mais uma vez que o conceito não é exclusivo da Indústria. *Lean* nos cuidados de Saúde é possivel e este trabalho pretende inspirar as Organizações de Saúde Portuguesas a adotar este tipo de soluções.

Palavras-Chave: *Lean*, Saúde, Oncologia, *Kaizen* Diário, SMED, *Benchmarking*, *Overall Equipment Effectiveness*, Fluxo do doente cirúrgico, Bloco Operatório

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"No institution can possibly survive if it needs geniuses or superman to manage it. It must be organized in such a way as to be able to get along under a leadership composed of average human beings."

Peter Drucker

Contents

Acronyms and Symbols

IPO FG Porto	Instituto Português de Oncologia Francisco Gentil Porto
KI	Kaizen Institute
OR	Operating Rooms
NHS	National Health System
ARS Norte	Administração Regional de Saúde do Norte
KPI	Key Performance Indicator
TPS	Toyota Production System
JIT	Just-In-Time
NHS	National Health System
VSM	Value Stream Mapping
PDCA	Plan Do Check Act
SMED	Single Minute Exchange of Dies
OEE	Overall Equipment Effectiveness
FCOTS	First Case On-Time Start
ORE	Operating Room Effectiveness
OA	Operational Assistant
EPE	Entidades Públicas Empresariais

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Chapter 1

Introduction

This dissertation, a project that emerged under the agreement between Kaizen Institute (KI) and Instituto Português de Oncologia Francisco Gentil do Porto (IPO FG Porto), aims do illustrate the application of Lean concepts in the Healthcare sector.

For over a decade, Lean, a concept that was born in the "industry of industries" as Peter Drucker dubbed it, and its methodologies have been successfully implemented in the service area, particularly in Healthcare (Kovacevic et al. (2016)). This project depicts the implementation of Lean Healthcare in a Public cancer care Hospital with the ultimate goal of eliminating waste in every process, procedure and task by establishing a continuous improvement culture.

Kaizen Institute, founded in 1985 by Masaaki Imai, provides consulting and training services in the continuous improvement area, being one of the major responsible for implementing Lean methodologies worldwide.

1.1 Project's framing and motivation

Worldwide, Healthcare systems are confronted with increasing costs and ageing populations, (Kaplan and Porter (2011)). Moreover, the COVID-19 health crisis exposed capacity issues and resource scarcity (Kumar (2021)), which are compelling organizations to improve workflow inefficiencies and increase focus on value adding Healthcare for patients.

According to the OECD (2021) report on Portugal's Health Profile, the country spends about one third below the EU average on Healthcare, a value that in 2019 amounted up to EUR 2,314 per capita. Between the years of 2013 and 2019 public spending on Healthcare grew steadily at a modest rate and in 2020, in response to the COVID-19 pandemic, which severely stretched the National Health System (NHS), public funding increased significantly. Furthermore, the report highlights the impact that cancer represents in national health, stating that solely in 2020 it was expected 58,000 new cases of cancer and about 30,000 cancer related deaths. Comparing the country with the rest of the EU, cancer detection and survival rates are high and similar to the EU average. In 2020, the pandemic gravely impacted patient care, delaying diagnosis and treatments, as corroborated by Morais et al. (2021).

These factors combined, scarce public funding, allocation of resources towards the COVID-19 crises and the pressing issue of cancer care, call for measures regarding a more efficient utilization of Healthcare resources and, at the same time, providing a top quality service, which can only be achieved through the application of Lean and Kaizen concepts.

IPO FG Porto, as one of the major Portuguese cancer care Institutions is at a particularly sensitive situation and it's imperative to ensure the efficiency of its processes. The project targeted the optimization of the Surgical Patient flow, dividing it in two stages: the First Appointment and Planning stage and the Check-In, Hospitalization and Surgery stage, where the main focus was the Operating Room (OR).

1.2 Project Description

In Portugal, the first steps towards the fight against cancer were taken around 1907 with the work of Professor Francisco Soares Branco Gentil. In 1923, the Instituto Português de Oncologia Francisco Gentil, IPO FG, was founded with headquarters in Lisbon. The IPO FG center in Coimbra first opened doors in 1967.

The IPO FG center in Porto, where this project was conducted, started its construction in 1968 and officially initiated operations in April 1974. It's considered one of the biggest cancer care Institutions at national level. In 1987, IPO FG Porto changed guardianship from the Ministry of Education to the Ministry of Health. In 2002, due to a change in the paradigm of Healthcare management in the country, it became Instituto Português de Oncologia Francisco Gentil Porto S.A., and the institution began having different management practices in order to facilitate the control of expenses and increase the quality of the service provided. In 2005, as consequence of a new juridical modification, the S.A. Hospitals were converted in Public Business Entities (EPE), institutions with public management and financial and administrative autonomy. IPO FG Porto's mission is to provide on-time health care at a patient centered level, aiming towards continuous improvement of their service quality and their perceived quality. The organizational chart of the Institution is presented in Figure A.1 of Appendix A. The organization provides differentiated cancer care to more than 45,000 patients covering the entire cancer continuum and its area of direct influence covers the borders of the Administração Regional de Saúde do Norte (ARS Norte) including the regions of South Douro and Northern Aveiro. IPO-Porto (2018) and IPO-Porto (2017)

Typically patients arrive to the IPO FG Porto when an external entity indicates that, due to their condition, patients should be followed at the Institution. Afterwards, patients have their first appointments and after their diagnosis is fully consolidated, a treatment strategy is designed for them, whether is surgery, chemotherapy or radiotherapy, etc. This project's scope is to optimize the flow of the surgical patients within the institution, which starts at the First Surgical Appointment and ends when the patient is discharged after surgery, with a special focus on the efficiency of the operating rooms as well as on the reduction of rescheduled appointments.

The surgical patient flow is characterized by a First Surgical Appointment, a Group Appointment, a Planning Appointment and a Preoperative Appointment. The last step before hospitalization and surgery is the Anesthesia Appointment. Regarding the central OR, it has eight rooms installed, seven for scheduled procedures and one designated to emergencies. The OR functions from 08:00 h until 16:00 h on conventional production and from 16:00 h until 22:00 h on additional production. This project will only cover the conventional production.

1.3 Objectives

The main purpose of this project was to improve the Surgical Patient flow while enhancing the service level the Institution offers to its patients. This materialized into the redesign of the patient's circuit until arriving to surgery and the optimization of the OR, increasing its efficiency. To better pursue these goals, the following objectives were designed:

- Implement and foster a culture of continuous improvement;
- Reduce the number of rescheduled Appointments;
- Reduce the starting time of the OR;
- Reduce the turnover time between surgeries;
- Increase the OR's efficiency;
- Benchmark the Institution against its Industry peers.

1.4 Methodology

The methodology adopted was structured in 4 main stages:

- Diagnosis - The initial phase of the project. Here the goal was to fully characterize the current situation, identifying the main problems and improvement opportunities of the value stream by applying the Value Stream Mapping (VSM) tool;
- Design of Solutions - In this second phase, the future status was designed and solutions were created in order to implement the desired vision;
- Implementation - In this stage, solutions were implemented through improvement initiatives involving the client;
- Evaluation - In the final phase, the implementation's results were assessed in order to understand the degree of fulfilment of the goals initially proposed;

1.5 Structure

This dissertation is structured in 6 chapters. Chapter 1, the Introduction, provides a broad context for the work developed. Chapter 2, the literature review, intends to briefly summarize the state of the art, immediately followed by Chapter 3 where the problem is defined and properly explored. After describing the current situation, there's Chapter 4 where all methodology and improvement actions were fully described. Chapter 5 introduces the results of the project and Chapter 6 presents the discussion, where the main conclusions were identified as well as the ideas for future work.

Chapter 2

Literature Review

2.1 The Toyota Production System

The Toyota Production System, or TPS, was pioneered by Eiji Toyoda and Taiichi Ohno at the Toyota Motor Company after World War II. In an effort to catch up with the American Industry, Toyota arose as the number one player in the automotive industry, a position that the Japanese company holds to this day. TPS's ultimate focus is the total elimination of waste, based on two main pillars, as presented by Ohno (1988):

- Just-In-Time or JIT - Developed by Toyoda Kiichiro and later improved by his successors, JIT is the starting point of the Toyota Production System. It's the principle of producing exactly what is needed at the precise time it's needed which ultimately improves efficiency and eliminates waste, unevenness, and unreasonableness. Due to the complexity of most production systems, this idealistic flow state is very difficult to attain;

- Autonomation or Automation with human touch - In Ohno (1988)'s book, Autonomation (not automation) is described as the concept of applying human intelligence to machines as the only way to make machines work for people. A machine automated with a human touch is one that has an automatic stopping device attached, that can be easily triggered by human touch. This concept somehow changed managerial paradigms stating that an operator is no longer needed while the machine is perfectly working. The machine only gets human attention when an abnormality occurs and the machine stops, allowing for reductions in the number of operators and increases in production efficiency.

Liker et al. (2006) explained the Toyota Production System by presenting the 4Ps, a hierarchical model that intends to summarize, the key characteristics that allowed Toyota to thrive as an organization. Each of the 4Ps, comprises a set of principles that the author considers to be the lessons from the world's greatest manufacturer and that can help other organizations to pursue Toyota's example:

Philosophy

Toyota's leaders perceive the Company as a vehicle for adding value, not only to consumers but, most important of all, to the community.

Process

At Toyota there's a deep belief that by performing the right process, the right results will show up. So, if results are not the expected it's because there's a problem with the process.

People

Another key principle in Toyota, is the importance of respecting people, not only by providing them with a good and stress free work environment but also by challenging them to grow as individuals and professionals.

Problem Solving

At Toyota, in order to drive deep learn and growth in the organization, the company encourages its people to continuously search for root problems and solving them in a structured way.

2.2 Kaizen Business System

Masaaki Imai, the renown quality guru who worked with Taichii Ohno on spreading TPS' message worldwide, first introduced Kaizen as more than just continuous improvement. Kaizen is improvement implicating every person, performed everywhere and every day within an organization (Imai (1986)). Imai, further explored the Kaizen concept as a low-cost approach to improvement since its initiatives consist of small improvements as a consequence of a continuous effort, contrasting with the concept of disruptive innovation, mostly based on expensive investments (Imai (2012)).

Kaizen Institute (or KI) was founded by Masaaki Imai in 1985 in an effort to help companies to adopt Kaizen methodologies and strategies. At KI, the Kaizen Business System is supported by five fundamental pillars (Imai (2012) and Coimbra (2014)):

- Focus on Customer Value - Customers are at the center and every decision must be made considering the customer point of view and how he will be impacted;
- Crate an Efficient Flow - In order to create flow, waste must be eliminated;
- Be Gemba Oriented - Gemba is the Japanese word for workplace. In order to understand problems and their root causes and identify improvement opportunities it's crucial to thoroughly explore and observe the Gemba;
- Involve all People - Empower every layer of the organization, from managers to employees by considering theirs pains, problems and opinions and by giving them responsibility and trust.

- Be Scientific and Transparent - Always rely on data to support facts and reasoning. Apply visual management in order to intuitively convey messages and ideas.

2.3 Lean in Healthcare

In a book called *The Machine that changed the world*, a benchmark study on car manufacturers, Womack et al. (1990) first introduced Lean as a concept that had its roots in TPS.

A few years later, Womack and Jones (2003) defined Lean Thinking as doing more and more with less and less and characterized the concept through a set of 5 principles. These, adapted to the healthcare context, makeup the foundations for Lean Thinking in Healthcare, described by Westwood et al. (2007) as identifying the least wasteful way to provide better and safer healthcare to patients, with no delays:

- Specify Value - Value is defined by the ultimate customer, it's a specific product that meets customer's expectations and needs at a certain time and price. Defining value in an accurate way is the first critical step towards Lean Thinking. In Healthcare, value must be seen from the patient's perspective: small waiting times, quality treatments, no incidents, etc.;

- Understand the Value Stream - The second step is to characterize and map the value stream, i.e. the set of actions that lead a product through: problem solving tasks (from concept to design); information management tasks (from order-taking to delivery) and physical transformation tasks (from raw materials to finished products). When addressing the Healthcare sector, the value stream consists of the entire patient's journey. Tasks that create value and tasks that generate waste must be properly signalized;

- Create Flow - After stating the value and clarifying the value stream, the third step is to rethink tasks and make processes and value flow. For the patient, this translates into the elimination of all barriers that prevent the quickest and safest flow of care (no queuing, no batches, no duplicate referrals, etc.);

- Incite customers to Pull - The fourth principle is to allow customers to pull value instead of constantly pushing it towards them. This means answering to demand, rather than handing off patients and pushing them through the process;

- Strive for Perfection - After achieving the first four principles, the fifth comes through continuous improvement, by endlessly pursuing the ideal state. For the patient, striving for perfection is completing care on time, with the best outcome, comfort, and with no faults or incidents.

It's hard to state precisely when Healthcare Organizations started to implement Lean philosophy. There are some reports of US hospitals that started implementing Lean methods in the 1990s, for example, Seattle Children's Hospital can trace its Lean journey back to 1996, according to Graban (2016). However, it's clear that, since the early 2000s, Lean Healthcare has been gaining expression between researchers worldwide, with a growing number of publications broadcasting different practical applications, concepts, tools, frameworks and methodologies (D'Andreamatteo et al. (2015)). Organizations such as the Institute for Healthcare Improvement in the US (Womack and Miller (2005), the NHS Institute for Innovation and Improvement (Westwood et al. (2007)) and the NHS confederation (Jones and Mitchell (2006)) soon recognized the value of implementing Lean Thinking in the Healthcare sector stating its advantages in driving out waste, reinforcing value-adding activities while improving safety, quality and staff satisfaction and, at the same time, reducing costs.

According to Morell-Santandreu et al. (2020), even though the interest in Lean Thinking and continuous improvement in the Healthcare sector has been growing in the last decade, few organizations have managed to fully implement and, most difficult of all, sustain Lean initiatives. In fact, Amran et al. (2020), in a study conducted at a government service Hospital, stated that the most critical barriers to success in Lean Healthcare implementation consist of: lack of qualified people in Healthcare services to teach or guide about Lean transition; lack of outside facilitator with expertise in Lean to guide the transition; lack of philosophy and knowledge in Lean Healthcare; absence of leadership empowerment; lack of employee empowerment and involvement. This research corroborates de Souza and Pidd (2011) findings that claim that the implementation barriers for Lean Healthcare, namely: Lean's specific terminology; the perception that Lean is exclusively a manufacturing concept; healthcare professional's personal and professional skills; hierarchy and management roles; side effects caused by data collection and performance measurement; resistance to change; organisational momentum and the existence of functional and professional groups (in opposition to the creation of flow), have considerably delayed Lean's adoption compared to manufacturing contexts. Graban (2016) also recognizes that Lean may sound as a very simple set of principles and concepts, however its implementation can be demanding. Implementing and most of all sustaining Lean in Healthcare is, therefore, a challenge.

In Portugal, few are the implementation cases documented in literature. Castro et al. (2020) presents a project in the Hospital Pharmacy of a local health unit in greater Oporto, designed specially to assist home patients, where Lean Healthcare tools such as Kanban, Advanced Pharmacies, operational indicators and visual management, resulted in the improvement of productivity, increasing the service level offered to patients as well as reducing costs.

2.3.1 Value and Waste

Pyzdek (2021) states that Lean is all about eliminating waste in value streams, but to do so, it's crucial to learn how to identify waste so that we can tackle it as effectively as possible. Originally, Ohno (1988) identified seven types of waste and Graban (2016), corroborated by Pyzdek (2021), adapted them to the Healthcare context, by exploring eight waste typologies:

- Defects - Time wasted on doing something the wrong way, inspecting or fixing errors. In the Healthcare context, errors are particularly critical since they can lead to injuries or even death. A good example of this type of waste could be the administration of a wrong medicine or dose to a patient;

- Over producing - Producing more than what the customer is expecting or producing it before it's needed. In the Healthcare sector this can be translated into unnecessary exams as an example;

- Transportation - Unnecessary movement of the product. For example, poor layouts in hospital facilities may cause patients, equipment, specimens or even medications to move unnecessarily;

- Waiting - Waiting for the next event to happen or waiting for the next operation/work activity. In Healthcare, waiting is endemic. Patients often wait long periods of time to receive treatments, appointments or even to be discharged;

- Inventory - Excess inventory leads to financial, storage, movement and wastage costs. It can also lead to expired supplies, materials or even medicines.

- Motion - Unnecessary movement by employees. Physicians and Nurses usually waste time searching for equipment or information.

- Over processing - Performing work that is not valued by the customer. In the health sector over processing can be the act of introducing information in the system that is not going to be used or giving information to the patient that is not useful to him;

- Human Potential - Failing to engage employees, disregarding their suggestions or ideas. Healthcare professionals may become demotivated when they feel their opinions are not being valued.

In opposition to waste, there's value added, and when classifying employee's work, there are value-adding activities and non value-adding activities. The distinction is based on the work being done at a specific moment and whether or not it adds value to the customer, or in this case, the patient. In an Healthcare context, the distinction between value-adding and non value-adding activities becomes specially difficult. For a surgeon, a value-adding activity might be actively operating a patient while a non value-adding one might be reopening a patient in order to retrieve a lost item. For a nurse, adding value can be the act of administering a medicine to a patient, while, in opposition, not adding value can be the act of copying data from paper to a computer.(Pyzdek (2021))

Banishing waste and generating value requires a very rigorous and systematic approach and that's why many Lean methodologies are so structured, like the "5 Ss", or the "5 whys" or the seven types of waste, as maintained by Womack and Jones (2003).

2.3.2 Value Stream Mapping

Rother and Shook (1999) described Value Stream Mapping, or VSM, as a "pencil and paper tool" that provides the whole picture of a process. The definition is simple, to follow and register the path of a product, from customer to supplier. Typically, using this method, two distinct visual representations are presented, the information flow and material flow. The goal is to have a value stream perspective and work on improvements for the whole stream and not just for a single and isolated process. Liker et al. (2006) point out that VSM is not just a visualization tool, it's a methodology of how to approach improvement. VSM highlights the waste present in all flow, it allows to identify linked processes and helps to envision the future and ideal state. Concerning VSM application, Rother and Shook (1999) resumed it in four steps:

1. Select a product family (each product family consist of a value stream);
2. Draw the current state map (CSM) with data from the process;
3. Draw the future state map (FSM);
4. Develop an implementation plan in order to reach the future state.

According to the study performed by Shou et al. (2017), VSM is one of the most used methods in what comes to Lean Healthcare and it's used to map administrative processes as well as patient treatment procedures. In terms of metrics to depict the current state, in Healthcare contexts, they usually are time-related, like lead times and processing times. Regarding the techniques to design the future state, the most common approach is to improve efficiency in the patient care flow. When addressing the advantages of VSM implementation in the sector, it was pointed out that, besides the reduction of the non-value-added time and improved service process efficiency, organizations witnessed reductions in employees' overtime and customer complaints (in administrative processes) and reductions in waiting times and treatment times (in patient flows). Nowak et al. (2017) also supported these findings by stating that VSM seems to have a particular impact in reducing non-value-added time such as waiting times and length of stay, increasing value for the patient.

2.3.3 Daily Kaizen

Imai (2012) resorts to a case study to present Daily Kaizen as a tool that allows leaders to convey the improvement initiatives through every layer of the organization. It can be decomposed in four different stages: Daily Management, Workplace Management, Standardization and PDCA (Plan, Do, Check, Act) cycle.

The first stage, Daily Management, is the most relevant to this dissertation and consists of short daily meetings (5 to 10 minutes) with visual support, usually a whiteboard, with several key elements. An agenda of the meeting is the first one, with its duration, its starting time and all the topics that must be discussed so that the conversation doesn't disperse. There's also the attendance map, where the presence of the elements is registered in order to keep track. One of the most important elements of the board is the team's Key Performance Indicators, KPIs, that must be clearly presented and easy to interpret. Another element is the work plan where all team members can have visual access to their assigned tasks. Finally there's the improvement cycle where the team registers the improvement opportunities that arose from any deviations regarding the KPIs, as well as the team member responsible for it and the date established for its implementation. Usually, these meetings take place in the beginning of the day or shift and after checking presences, the team addresses the challenges presented at the previous work day, then focuses on their KPIs and on identifying improvement opportunities or countermeasures for when objectives are not being met and, finally, the meeting ends with a review of the work plan for the current day.

Imai (2012) also highlights that Daily Kaizen increases staff motivation and stimulates participation. It also allows for a better management of the daily tasks, increases service and product quality and positively contributes to the work environment. Zarbo et al. (2015) illustrates the impact of daily management by presenting a case study at the Henry Ford Hospital in Detroit where a visual daily management board was designed and Daily Kaizen was implemented. It resulted in 42 process improvements within 1 year of monitoring and the authors concluded that daily management allows for a more efficient culture of continuous improvement.

2.3.4 Standardized Work

According to Graban (2016), Standardized Work is used to maintain productivity, quality and safety and it's defined as the act of finding the current best possible way of safely performing a task with proper outcome and high quality, with the fewest resources possible and documenting it in a clear way so that everyone within the organization is fully aware of it and performs it accordingly. Typically Hospitals have their procedures fully described and characterized, however, it's very common to find different people performing the same task in different ways or not performing it in the best way possible. The author presents the example of the University of Kansas Hospital where a simple Gemba observation performed by the administration uncovered 171 different registration forms just for ambulatory care. The team was able to reduce these forms to 6 standardized ones, saving money and space, reducing confusion and errors. Regarding the practicability of these Standardized Work documents, they can assume many formats, such as: Standardized work charts with job responsibilities, common tasks, how long they should take and a diagram showing where the work is performed; Work combination sheets, which synchronize both the operator's and the machine's work; process capacity sheet; detailed work instructions, which details important tasks; cycle balance charts; etc. Whatever format chosen to document the Standardization, the author calls the attention for the importance of making sure that the document is created by the actual people who will be performing the work, and again gives another elucidating example: in Geisinger Health System in Pennsylvania, a group of cardiac surgeons discovered that different protocols were being used by different professionals. The team of surgeons reviewed guidelines and literature and based on their experience came up with a 40-step document that standardized the coronary artery bypass graft procedure. The patient outcomes were outstanding with a reduction of 44% on readmission dates, a reduction of 21% in patients with at least one complication, a 55%

reduction of re-operations due to bleeding, a reduction of 25% in deep sternal wound infections and even a 17% increase in profit margin.

2.3.5 SMED - Single Minute Exchange of Dies

SMED was introduced by Shigeo Shingo at Toyota, and Pyzdek (2021) characterizes it as a Lean tool for reducing waste by allowing for fast changeovers. SMED stands for single minute exchange of dies and it means that changeovers should take less than 10 minutes. It consists of several stages:

1. Work study - Go to the workplace and identify tasks, classifying them as external or internal. An external task is the one that can be performed while equipment is still running, on the other hand, an internal task is the one that can only be performed when work is stopped. For example, in an OR, an internal task could be to mop the floor, which requires the surgical procedure to be over, and an external one could be to previously prepare the material for the next surgery, which can be done while the current patient is still under intervention;

2. Separate External from Internal work - Clearly segregate the work that can be performed before, during or after the setup time.;

3. Shift Internal work to External - Since internal work requires the operation to be interrupted, the main goal is to shift these tasks to external work, so that they can be performed while the process is still running;

4. Minimize Internal work - The ultimate goal is to reduce the internal work to the bare minimum, to ensure that the process is on hold for the least amount of time possible;

5. Minimize External work - Although external work doesn't have a direct impact on setup time, it consumes resources and adds up to complexity.

After these stages, it's important to standardize the work sequence, detailing which tasks must be performed, with what tools, where, by whom, and how much time should they consume.

Calero et al. (2020) at the emergency service of a private Peruvian health clinic managed to, by applying SMED techniques, reduce patient waiting times by 30% during the first medical examination as well as reduce the triage care times by 40%.

2.4 Measuring and Benchmarking OR's performance

Citing Rothstein and Raval (2018), Operating Rooms are complex environments with multi-hierarchical social interactions (physicians, nurses, interns, operational assistants, etc.), unpredictability, low tolerance for mistakes, and high expectations. According to Healey et al. (2015), operating rooms generate significant revenue for Healthcare Organizations yet, they are also a critical piece of its cost structure, accounting for about 35% to 40% of total costs. The cost of running an OR is estimated to be $15-20 per minute. (Macario (2010)).

Considering how critic they are to Hospital's cost structure, improving OR efficiency is a pressing issue that can lead to, not only financial savings, but improvements in patient safety and satisfaction, OR throughput (more surgeries), and even staff motivation. In order to improve their OR's performance, it's essential for Healthcare organizations to first understand how to measure it (Rothstein and Raval (2018)).

In fact, Hospitals should monitor, on an ongoing basis, their ORs performance as well as benchmark it both internally and externally in light of continuous performance improvement. To do so, a set of key performance indicators must be selected and continuously tracked. The issue lies on identifying which variables are the most significant. On one hand there appears to be variation among Healthcare Organizations in terms of which indicators should be selected in order to effectively track performance in ORs and, on the other, considering the diverse group of stakeholders involved — hospital administrators, surgeons, patients, anesthesiologists, nurses, etc. — it's often difficult to reach consensus on the subject. This poses critical challenges for external benchmarking since only with uniform measures and clear and concise indicator definitions can hospitals begin to benchmark and ultimately learn and adopt each other's best practices (Fixler and Wright (2013)).

As stated by Lee et al. (2019), there isn't a single metric specially designed, standardized and tested to evaluate performance and efficiency in what regards surgical care. However, there are multiple alternative solutions covered in literature.

Procedure Cancellation Rate

Unexpected same-day cancellations of surgical procedures result in significant losses for Healthcare organizations (Lee et al. (2019)). Talalwah and McIltrot (2019) stated that surgery cancellations lead to waste of resources, patient dissatisfaction and increasing Healthcare costs. However, most annulment causes are preventable and the author identified three principal clusters of surgery cancellations:

- Hospital-related cancellations - Cancellations that occurred due to administrative or logistic issues intrinsic to the organization, such as unavailable OR time, prioritization of emergency cases, failed or missing equipment, insufficient planning, lack of hospital beds or personnel;

- Patient-related cancellations - Includes patient absenteeism, self-cancellation, financial constraints, medical reasons and inadequate preoperative assessment;

- Surgeon-related cancellations - Physician-related causes like, unavailability of the surgeon, lack of anesthesia staff, failure to administer anesthesia, and over-booking.

Talalwah and McIltrot (2019) also pointed out the high rate of cancellations due to hospital reasons with the leading cause being the lack of OR time.

FCOTS - First case on-time start

First case on time starts measures the percentage of first cases of the day that start punctually, as they were scheduled. Typically, a case starts on time when the patient enters the OR at the time that the procedure was scheduled. Moreover, some hospitals give a grace period of between 0 to 15 minutes to account for some delays intrinsic to the start of the day at an OR. An alternative definition of start time is the time of incision (using this definition as its advantages since it captures the tardiness of the OR elements in general since in order to start the incision on the patient's body, all OR staff and essential equipment must be present before the procedure can be initiated) (Fixler and Wright (2013)). Chapman et al. (2020) affirm that avoiding delays in the first cases of the day increases OR utilization and improves the on time conclusion of the last cases, which, in consequence, translates into less costs of OR overtime and reduces staff conflicts and overall frustration. The authors also identify the key parameters for a successful improvement of FCOTS:

- Provide a clear definition of FCOTS - as previously mentioned, the indicator can be measured in multiple ways and it's important that OR staff is aligned in a clear definition of the indicator. This allows staff to pursue a common goal;

- Early identification of factors leading to delayed starts;

- Establishing a system of data collection and monitoring - providing staff with methods of continuously tracking progress will lead to the immediate identification of failures and their root causes in real time;

- Short-interval feedback to stakeholders - immediate feedback enables rapid corrections so that causes of delayed starts are corrected.

Furthermore, following the research done by Kane et al. (2021) where the FCOTS increased from 61.6% to 66.9% through an incentive program where attending surgeons attested their presence in the OR via text message or identification badge, Dobson and Tsai (2021) highlight that since organizational changes within the operating theatres happen as a result of multidisciplinary collaboration, the developing of flexible definitions for start times might further improve clinical workflows. The authors also provide an example: if a patient needs preoperative nerve, the start time can be registered when the anesthesiologist begins to perform the technique and not when the patient enters the Operating Room.

A multi-center research conducted by Joos et al. (2021) unveiled a large variety of causes leading to the lack of punctuality in the first cases of the day, which ultimately explain why eliminating, or even reducing, delays is such a challenging task. According to the study, prolonged anesthesia induction is responsible for approximately half of the delayed cases. The other half is caused by a variety of reasons, ranging from administrative issues to patient tardiness on arriving to the hospital and availability of personnel, which depicts the complex interaction of OR processes with other workflows within the hospital.

Other studies also show that anesthesia technique and specialty are relevant factors that influence the procedure start time. However, poor planning and scheduling process were also identified as one of the most important drivers of delay of start times.(Does et al. (2009)).

OR utilization

The utilization rate, as its name suggests, represents the percentage of OR time that is actually used to perform planned surgical procedures, leaving out turnovers and preparation times, Lee et al. (2019).

According to Charlesworth and Pandit (2020) the advantage of this metric is that it gives a clear picture of the utilization of theatre rooms as a critical resource. However the authors defend that its sole utilization may lead to overbooking of the surgical plan since high utilization can only be achieved by over-running. In another perspective, when under-running the team may perform their work slowly so that the day doesn't finish early.

Operating room turnover time

The turnover time, much like an industry setup time, is the time interval between the exit of a patient until the next incoming patient enters the room. This includes time to properly clean and organize the operating room (removing trash, cleaning surfaces and the floor, changing the bed, etc.) and prepare the necessary staff and equipment (acquiring positioning devices, opening supplies and instruments, preparing the table, completing the count, preparing medications, etc.) (Lee et al. (2019)).

OEE - Overall Equipment Effectiveness

Stamatis (2010) describes the overall equipment effectiveness, OEE, as essential in measuring both productivity and efficiency. In a manufacturing context, OEE is a hierarchy of measures that depicts how effectively a manufacturing operation is being utilized. Due to its nature, OEE allows for comparison between machines, factories, departments, manufacturing cells and even industries. It gives an overview of equipment potential, tracking losses and identifying opportunities for improvement.

The index comprises three types of manufacturing wastes which unfold in seven types of losses, as we can see in more detail in table 2.1.

The Effectiveness index can be computed either by simply applying its equations or by using the Time Loss or Unit Loss models, as mentioned by Kennedy (2018).

The Equation 2.1 represents how to calculate OEE and Equations 2.2, 2.3 and 2.4 illustrate how to compute the three indexes, the Availability index, the Quality index and the Performance index, respectively.

$$\text{OEE} = \%\text{Availability} \times \%\text{Performance} \times \%\text{Quality} \tag{2.1}$$

Table 2.1: The basic production losses represented in the OEE (adapted from Kennedy (2018))

Classes	***Losses***
Availability	Planned Downtime Setup Downtime Unplanned Recorded Downtime
Performance	Reduced Speed Minor Unrecorded Stoppages
Quality	Rejects and Rework Start-up and Yield

$$\text{Availability} = \frac{\text{Available Time} - \text{Planned Downtime}}{\text{Available Time}} \tag{2.2}$$

$$\text{Quality} = \frac{\text{Total Parts Produced} - \text{Defects}}{\text{Total Parts Produced}} \tag{2.3}$$

$$\text{Performance} = \frac{\text{Real Speed}}{\text{Ideal Speed}} \times \frac{\text{Total Parts Produced}}{\text{Reported Production Time} \times \text{Real Speed}} \tag{2.4}$$

The second and third alternative to calculate OEE, are the Time Loss and the Unit Loss model. These methods resort to continuous data collection, clearly identifying the actual time lost or units lost on each of the manufacturing waste categories previously identified, allowing for better focus on improvement activities. The time loss model, represented in figure 2.1, calculates OEE as a ratio between the value adding time (the total production available time minus all time wasted in Downtime, rate losses and quality losses) and the total available time, or the production crew time. The Unit Loss model, schematized in figure 2.2, resembles the Time Loss one, but instead of performing the calculations in a time basis, the model resorts to production units. In this case OEE is calculated as the ratio between good units produced (units produced under quality requirements at the first attempt) under the total number of units that should be produced given the available time.

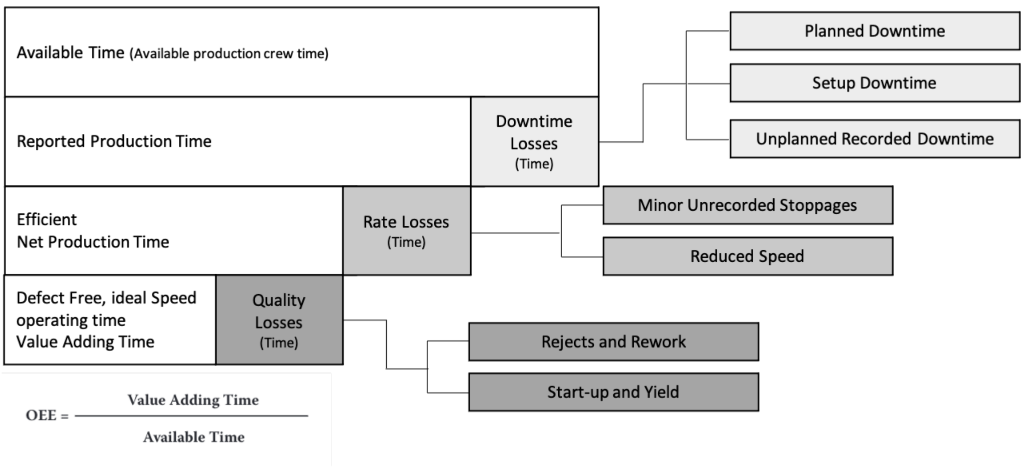

Figure 2.1: Time Model, adapted from Kennedy (2018)

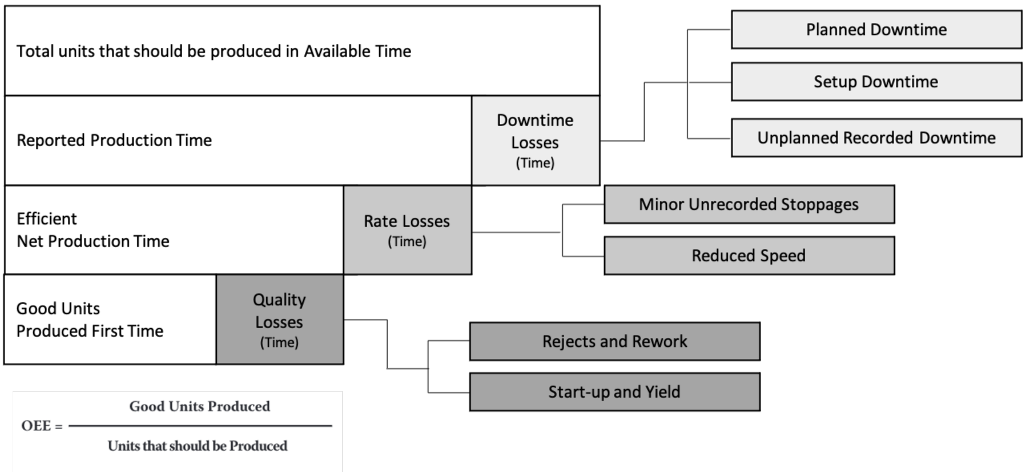

Figure 2.2: Unit Model, adapted from Kennedy (2018)

Regarding the application of OEE outside manufacturing contexts, Souza et al. (2020) propose an adaptation of OEE in order to measure the Operating Room's performance, the Operating Room Effectiveness, or ORE, which the author classifies as a Lean performance indicator focused on the surgical flow and its particularities, that allows to scrutinize the different types of operational losses that may happen in the Healthcare context, namely in operating theatres. The ORE, much like the OEE, also refers to the three main classes of losses, however the losses represented in each class were adapted to the OR context, as depicted in table 2.2.

Table 2.2: The basic OR losses represented in the ORE, adapted from Souza et al. (2020)

Classes	***Losses***
Availability	Equipment Failure Set-up and Scheduled Shutdowns Not Scheduling
Performance	Small Shutdowns Variation in Surgery Time Cancellations
Quality	Surgical Re-interventions

Just like OEE, the ORE is obtained by multiplying the availability, the performance and the quality index or by computing the ratio between the total time of added value and the total available OR time.

When addressing Operating Rooms, the availability is the total time available for performing surgeries, or, in a more practical point of view the total time available for scheduling procedures. The availability index, as demonstrated in the Equation 2.5, and supported by figure 2.3, is calculated by the fraction between the total time available minus the time lost due to equipment failures, such as planned shutdowns for maintenance, setups, which include room cleaning and preparation and idleness caused by not scheduled surgeries and the total time available.

$$\text{Availability} = \frac{\text{Total Available OR Time} - \text{Equipment Failure} - \text{Setup} - \text{Not Scheduling}}{\text{Total Available OR Time}} \tag{2.5}$$

The OR's performance is the ratio between the total time effectively used and the total OR time scheduled. The total time effectively used is calculated as the total OR time scheduled minus the time that was lost in short shutdowns (caused by equipment problems, or momentary lack of surgical supplies, for example), variation in standard surgery time (which can be consequence of complications related to the patient or the procedure itself or even due to the professional's experience) and surgery cancellations. The Performance's expression is depicted in the Equation 2.6 and is also explained in figure 2.3.

$$\text{Performance} = \frac{\text{Total Time Scheduled} - \text{Small Shutdowns} - \text{Variation In Surgery Times} - \text{Cancellations}}{\text{Total Time Scheduled}} \tag{2.6}$$

The Quality index is measured as the ratio between the total time of added value and the total time used. The total time of added value is defined as the total time used subtracted from the time spent on surgical re-interventions caused by surgical failures or errors. The Quality index's expression is represented in Equation 2.7 and is schematized in figure 2.3.

$$\text{Quality} = \frac{\text{Total Time Used} - \text{Surgical Re-interventions}}{\text{Total Time Used}} \tag{2.7}$$

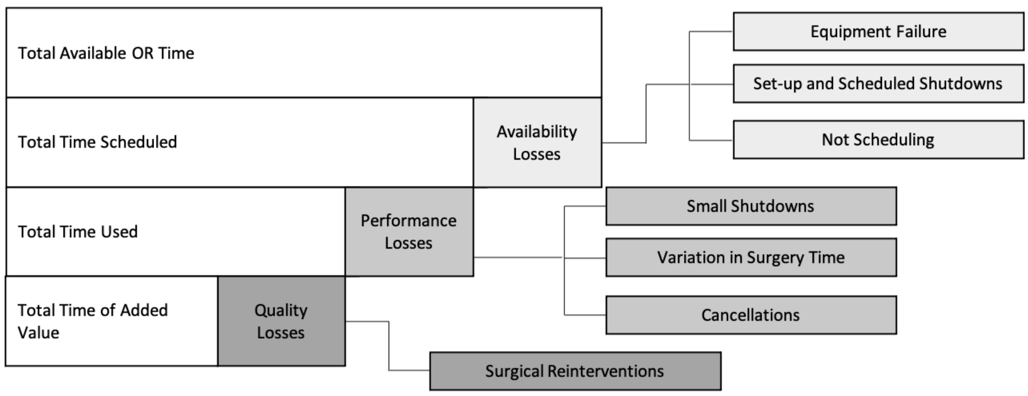

Figure 2.3: Time Model adjusted to OR context, adapted from Souza et al. (2020)

The implementation of this indicator at a large university hospital in southern Brazil and the further development of improvement actions, reached an efficiency gain of 12% with estimated annual savings of US$ 400,000.

Chapter 3

Problem Description and Diagnosis

3.1 Introduction

Following the Value Stream Mapping methodology, in this chapter the current state of the Surgical Patient flow will be fully characterized, from the moment the patient has its First Surgical Appointment until the moment he is discharged after Surgery. The analysis was divided in two stages, to facilitate interpretation, the First Surgical Appointment and Planning phase and the Check-In, Hospitalization and Surgery phase. Each of the stages can be further explored in terms of material flow (which, in this context translates into patient flow) and information flow. Bearing in mind the purpose of this dissertation only the patient flow will be scrutinized.

In order to correctly map the current situation, a multidisciplinary team was assembled with the Operating Room's Director and Nursing Chief, the Head of the Surgical Oncology Department, the Director of the Patient's Management Service and a member of the Surgery, Radiotherapy and Anesthesia Management Department. The group's enthusiasm, focus and critical spirit was the key that allowed for such an exhaustive analysis.

The data presented is this chapter was provided by the IPO FG Porto and it refers to the period between 2018 and October 2020 when the diagnosis phase of the project was conducted.

3.2 Patient Flow

First Appointment and Planning

As represented in Figure 3.1, patients, after being prescribed with surgical treatment, have a First Surgical Appointment at the Hospital, where doctors prescribe the exams required to fully evaluate the patient's condition (in case patients don't already bring them). Following this contact, the patient has a Group Appointment where specialized physicians conjointly present the therapeutic proposal. The next step is the Surgery Planning Appointment where the date and the hour of the surgery are set. The secretariat schedules the surgery, following the physician's indication. Then, the patient returns to the hospital to perform the Preoperative Appointment where his condition is reevaluated in order to understand the procedure's risk. Before hospitalization, the patient must perform a COVID-19 test, followed by the Anesthesia Appointment where all anaesthesia related parameters are defined. Normally patients show up for the Anaesthesia Appointment and are hospitalized on the same day, so that they can have surgery the following day.

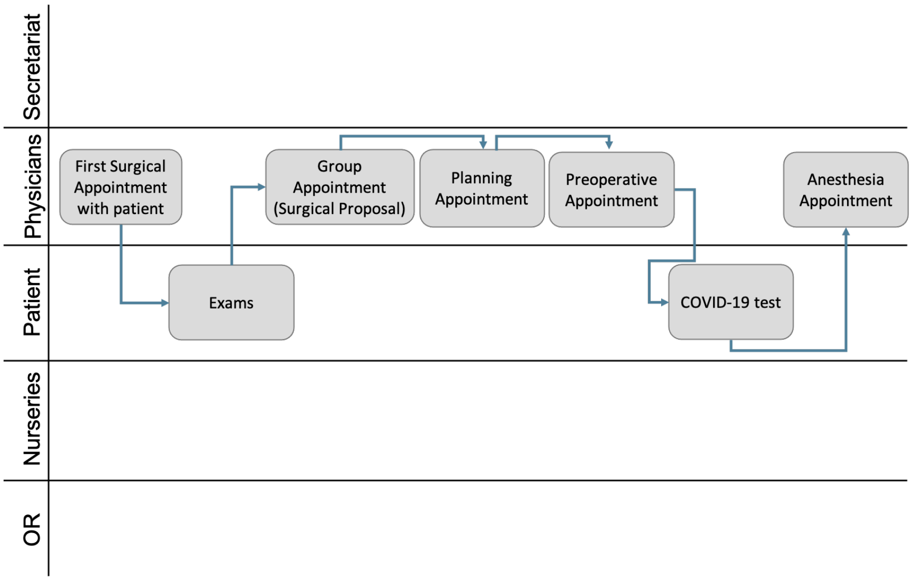

Figure 3.1: Surgical Patient Flow, from the First Surgical Appointment until the Anesthesia Appointment, the last step before hospitalization

Check-In, Hospitalization and Surgery

After the Anaesthesia Appointment, patients head to the secretariat in order to check-in for the hospitalization, which, considering the central OR's surgeries, typically happens the day before the procedure. The patient's administrative admission is immediately followed by the physical admission at the designated nursery. Each nursery is responsible for the preparation of its patients and at the moment that the patient needs to be transferred to the Operating Room, one of two situations might happen: the patient is one of the first surgeries of the day; or the patient is one of the other surgeries of the day. In the first surgeries of the day, the patient is transported to the OR admission at around 8:00 h, without being called by the OR staff, which originates difficulties at the OR entrance since the space is small, patients are transported in beds and there are 7 first surgeries in the morning (which means 7 patients waiting to be admitted). The morning admission process is performed in 4 stages: changing the bed (due to safety protocols, nursery beds can't enter the Operating Room so they must change the patient to an OR gurney), confirming the patient's information in the system, confirming patient's information with the patient and transporting the patient to the room (sometimes changing the gurney again, since the patient might need a specific gurney due to surgery particularities). Normally, when a first patient of the day enters the Operating Room, there's an Operational Assistant, OA, responsible for him, who accompanies the patient throughout the whole admission process. Furthermore, there are no workstations defined and as so, at the beginning of the day, there is always some confusion in who is responsible for the admission and who is performing which tasks. On the other hand, when it's not one of the first patients of the day, the Operating Room staff is responsible for contacting the nursery when it's the right time to transfer the patient. When the patient arrives, the admission process is done in a similar way. After entering the OR, patients are accompanied to their surgery room, where anaesthesia begins, followed by the surgical procedure. When the surgery is finished patients are transferred to the recovery room where they are kept under observation. When patients are discharged from recovery, the OR calls the nurseries so that they can take the patient and start the postoperative care. Clinical discharge is given by a physician and it's followed by an administrative discharge and a physical one, when the patient leaves his bed and the hospital.

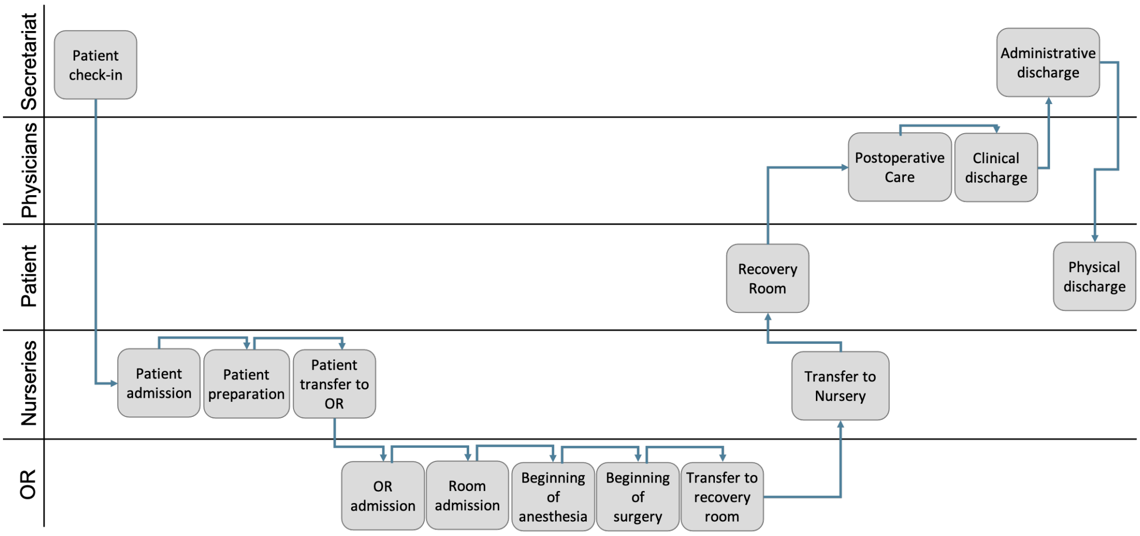

Figure 3.2: Surgical Patient Flow, from the patient's check-in for surgery until discharge from the hospital

Between surgeries, operational assistants are responsible for cleaning the operating room, preparing it for the next surgery. This process, typically, is performed by two assistants, one from the "red corridor" (the back of the Operating Room leads to a corridor that's destined to process the used equipment after a surgery) and one from the "white corridor" (the front end of the OR, from where patients enter the room, it's also where the clean equipment and utilities are stored before surgeries).

3.3 Data Analysis

Concerning data analysis, and more specifically the analysis performed to the OR start time, Wednesdays were left out, since it's a day where the mornings are dedicated to staff meetings. The schedule and duration of these meetings varied through the period that the data was collected, and as so it was considered that the inclusion of Wednesdays could skew conclusions.

Outliers were also reviewed. Turnovers with a duration of more than 35 minutes were left out of the analysis, since they probably represent theatres that ended their operation sooner than expected, or the room simply didn't have a next surgery allocated. Regarding the beginning of the day, first surgeries that started after 10:30 h were disregarded from the analysis since they most likely translated situations where the nurseries had problems in transporting patients to the OR (lack of consent, lack of necessary preoperative interventions, etc.)

Moreover, when measuring the OR start time and the turnover time, to robust the analysis both mean and median values where registered, since median values aren't influenced by outliers or atypical values and work better on data from skewed distributions.

Surgery Reschedules and Cancellations

In 2019, at the central Operating Room, 31% of all processes were rescheduled before culminating in actual surgery, i.e, the predicted date for the procedure had to be changed somewhere in the process. This highlights planning difficulties. Moreover, in 2020, between January and October, 2,020 surgeries were scheduled to happen at the hospital's central OR (conventional production). From these, 6% were canceled and Figure 3.3 depicts the distribution of the cancellation motives. Roughly 46% of the cancelled surgeries were due to lack of surgery time. Furthermore, 25% of all cancelled surgeries were caused by clinical motives. In order to get to the root cause of the cancellation issue, the team designed an ishikawa diagram, presented in Appendix B, Figure B.1. It was identified that the lack of OR time was due to tardiness at the beginning of the day at the OR, overbooking, surgery delays and same day alterations of the surgical approach. Addressing the clinical motives, besides patients whose condition deteriorated over night, it was highlighted that cancellations were caused by the fact that the preoperative evaluation was carried out too prior to the patient's check-in date and also due to patients arriving to the Operating Room or to the Anesthesia Appointment without the sufficient preoperative preparation.

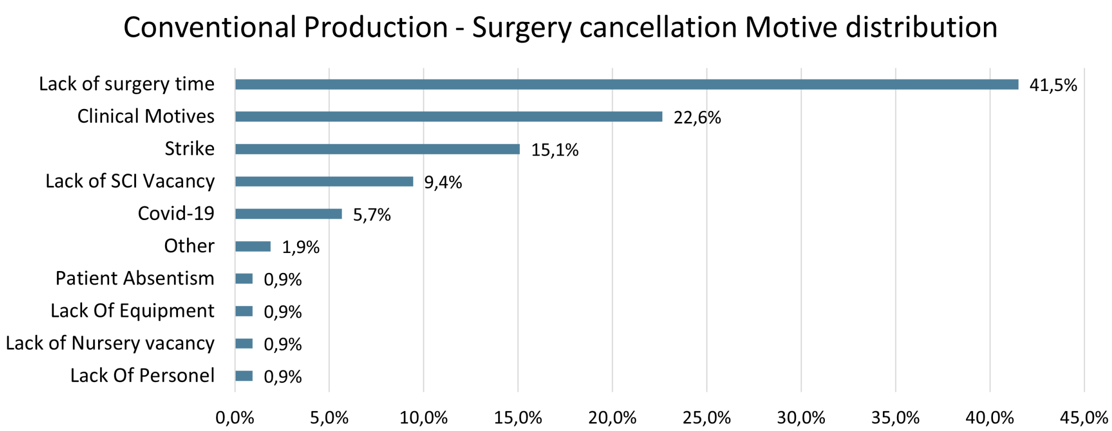

Figure 3.3: Distribution of Surgery Cancellation Motives for conventional Surgeries (period of analysis: January 2020 - October 2020)

Regarding the most affected surgical services, Neurosurgery stands out as the most harmed clinic with 17% of total cancellations, immediately followed by Plastic surgery and Urology with 11% and 9% respectively (Figure 3.4).

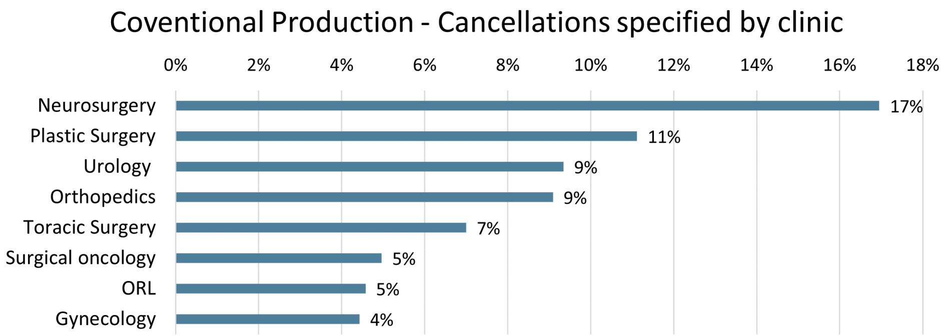

Figure 3.4: Cancellations specified by clinic (period of analysis: Jan-Oct 2020)

Operating Room Start time

To properly monitor the Operating Room start time, different indicators were selected so that the distinct stages of the OR morning start, could be quantified:

- OR arriving time - The time the first patients of the morning effectively enter the OR, which includes the first part of the admission process. The OR arriving time corresponds to the time the patient's information in checked in the system;
- Patient entering the room time - The actual time patients arrive to their assigned room. After having their information checked, patients are transported to their operating room, concluding the admission. This indicator allows to register the performance of the Operating Room admission process;
- Beginning of Anaesthesia - The precise time at which the induction of the patient begins;
- Beginning of surgery - The actual time the surgical intervention initiates, denominated in literature as the incision time.

Table 3.1 summarizes the evolution of the OR start times throughout the years, namely 2018, 2019 and 2020 (from January to October). Even though 2020 was an atypical year, due to the COVID-19 health crisis, the OR start times were practically the same over the period of analysis. It's showed that patients enter the OR, on average, at around 08:21 h and then enter the OR room at 08:37 h. Regarding anesthesia and surgery the start time's average are around 08:57 h and 09:27 h respectively.

Table 3.1: Mean and Median of the Operating Room start time measures over the years: OR arriving time, Patient entering the Room, beginning of anaesthesia, and the Beginning of surgery

Period	Patient entering the OR		Patient entering the room		Beginning of Anesthesia		Beginning of Surgery	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
2018	08:21 h	08:18 h	08:37 h	08:35 h	08:56 h	08:54 h	09:28 h	09:27 h
2019	08.22 h	08:20 h	08:37 h	08:35 h	08:56 h	08:55 h	09:25 h	09:25 h
2020 (Jan to Sep)	08:21 h	08:19 h	08:37 h	08:35 h	08:57 h	08:55 h	09:27 h	09:27 h

Figure 3.5 represents the distribution of the times patients are entering the OR segregated in 3 categories, in green, patients who enter the OR before 08:15 h, in yellow patients who enter between 08:15 h and 08.29 h and in red, patients who enter the OR after 08:30 h. Going deeper into the analysis it was observed that, regarding the 2020 values, only about 30% of the patients entered the OR before 08:15 h, same as in 2019.

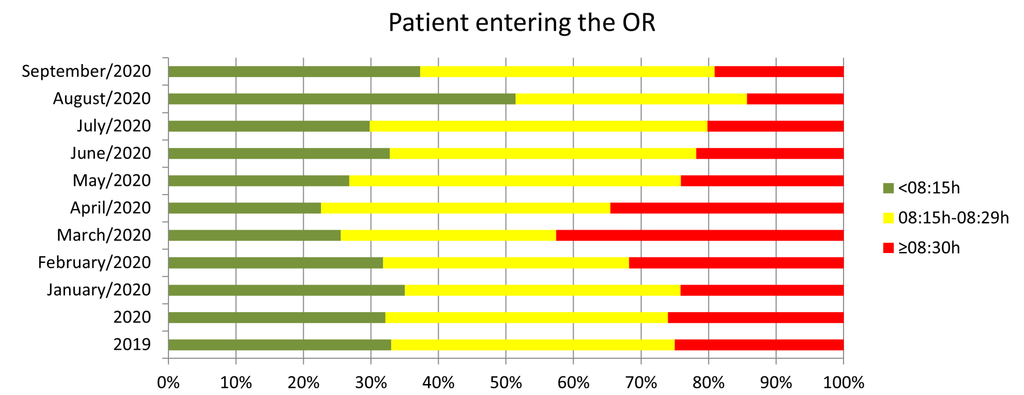

Figure 3.5: Patient entering the OR

Figure 3.6 provides the distribution of the times at which patients are entering the operating rooms, ready to start anesthesia. In green it's represented the patients entering the rooms before 08:30 h, in yellow, the patients entering between 08:31 h and 08:45 h and in red the patients who enter their assigned room after 08:45 h. It was highlighted that, in 2020 and 2019, only approximately 43% of the patients were entering their operating room before 08:30 h.

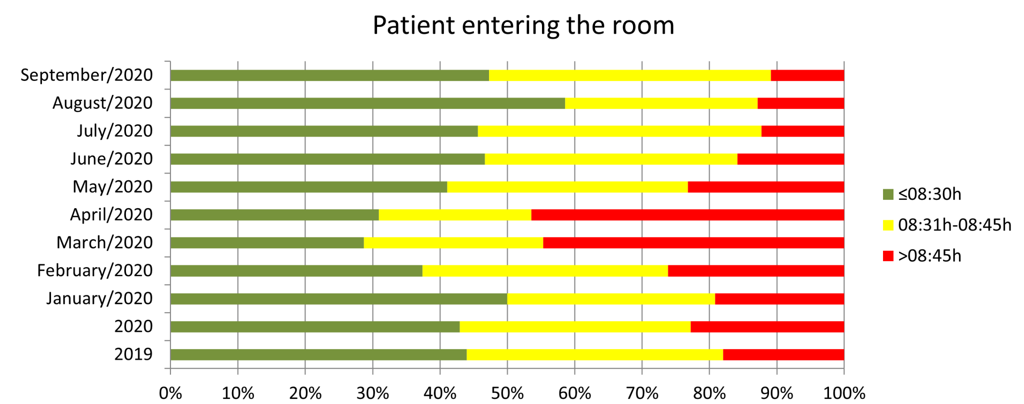

Figure 3.6: Patient entering the room

As for the start of anesthesia, Figure 3.7 depicts in blue the surgeries in which anesthesia started before 08:45 h. In green are represented surgeries in which anesthesia initiated between 08:46 h and 09:00 h. In yellow are depicted the procedures where anesthesia started between 09:01 h and 09:15 h. In orange and red are characterized the surgeries where anesthesia started between 09:16 h and 09:30 h and after 09:30 h respectively. Here it's interesting to point out that only in 20% of the cases the anesthesia is starting before 08:45 h, in the 2020 period. In 2019, this value was around 25%.

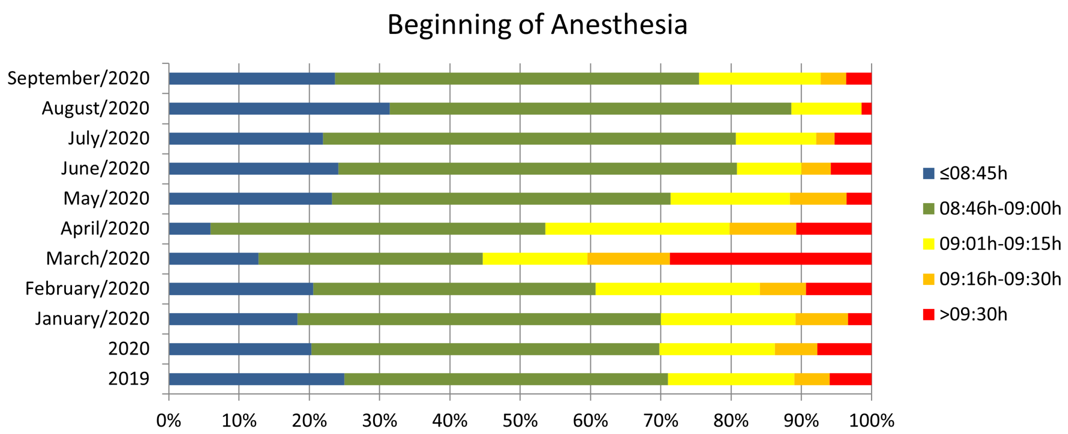

Figure 3.7: Beginning of Anesthesia

The delays at the beginning of the day severely impact the end of the last surgeries of the day, and in fact it can be seen, in Figure 3.8, that, in 2020, in 24% of the days, surgeries ended after the exiting hour, 16:00 h. The mean deviation was 49 minutes, meaning that in 24% of the working days, teams are ending their shift, on average at 16:49 h. This affects staff motivation, damaging the morale of teams whose work is already endemically stressful. Furthermore, over-running the OR, as analysed in Chapter 2, also increases costs.

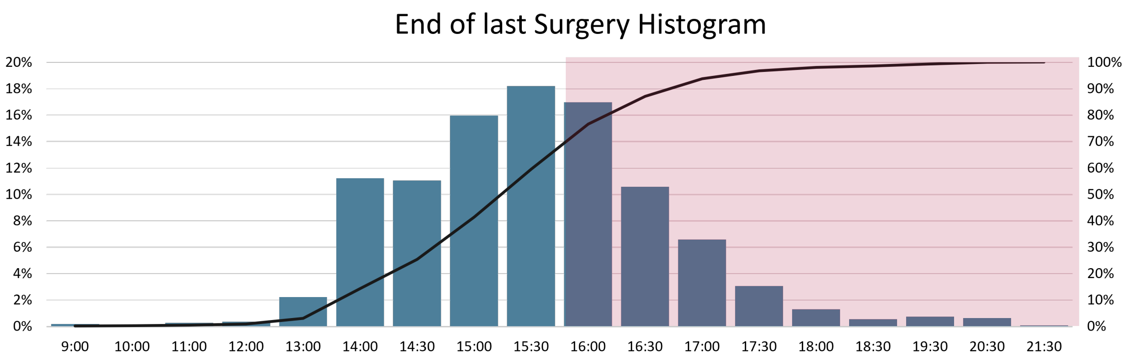

Figure 3.8: End of last surgery histogram (period of analysis: Jan-Oct 2020)

Second Patient

As has been described in this Chapter, the 7 first patients of the Operating Room are independently transported by the nurseries to the OR at 08:00 h in the morning. However, regarding the second, third and fourth patients, the process is different. When OR nurses, who are responsible for each first surgery, notice that the procedure is about to end, they contact the nursery where the next patient is hospitalized, so that he can be transported to the OR. Figure 3.9 translates the delays in this process since only 37% of the patients arrive at least less than 5 minutes before the turnover ends. The mean delay is about 13 minutes.

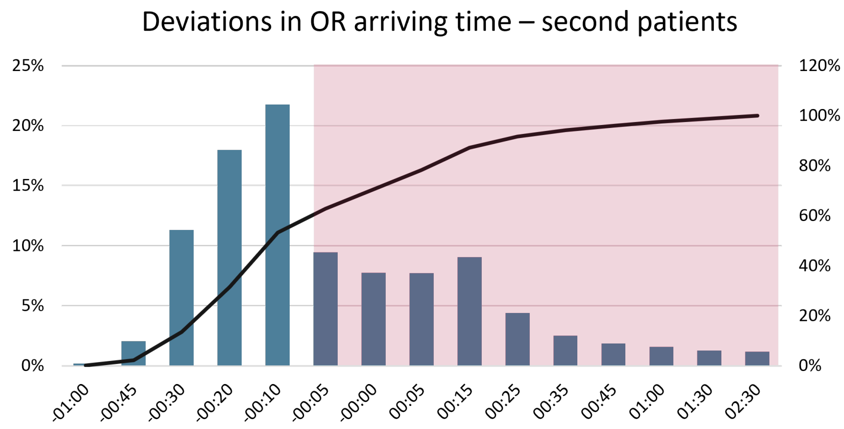

Figure 3.9: Deviation in the OR arriving time - Second patients (period of analysis: Jan-Oct 2020)

Turnover Time

The turnover time which was defined as the time interval between a patient who, after the surgery, is transported to the recovery room, until the next patient enters the room. Figure 3.10 illustrates how the hospital was performing regarding this indicator. The values stayed stable throughout 2018 and 2019 and the peak in 2020 corresponds to the consequences of the COVID-19 pandemic.

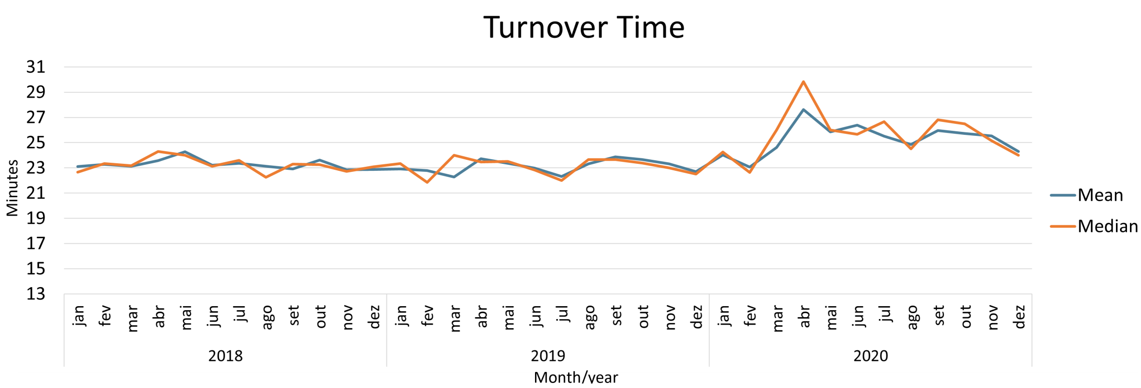

Figure 3.10: Turnover Time

As seen in Table 3.2, in 2018 the mean turnover time was around 23 minutes, as well as in 2019. In 2020 the mean rose up to more than 25 minutes which, as previously mentioned, can be explained by the pandemic's impact on cleaning protocols.

Table 3.2: Mean and Median of turnover time, summarized by year

Year	Mean	Median
2018	23,3 min	23,2 min
2019	23,1 min	23,4 min
2020 (Jan - Set)	25,3 min	26,0 min

3.4 Improvement Opportunities

First Appointment and Planning

The main improvement opportunities identified at the First Appointment and Planning stage were:

- Lack of necessary exams when the patient arrives for the First Surgical Appointment;
- Lack of vacancies to schedule and perform exams at the desired date;
- Variability in planning methods;
- Lack of requested exams and complete studies by the time the patient reaches the Group Appointment. When the complete patient studies are not available, the physicians at the Group Appointment take one of two actions, reschedule the appointment or make a decision, if possible. This decision stays dependent on late exams, however, the patient moves forward to the next Appointment;
- Lack of scheduling for COVID-19 tests;
- Alterations in patient's condition by the time he reaches the Anesthesia Appointment;
- High lead time between patient evaluation and patient check-in for surgery;
- Patient condition's study incomplete by the time he reaches the Anaesthesia Appointment (lack of exams for example);
- Constant rescheduling of Appointments due to alterations in the patient's condition that were only detected by the time late exams arrived.

Check-In, Hospitalization and Surgery

The main improvement opportunities identified at the Check-In, Hospitalization and Surgery stage were:

- Excessive waiting times to check-in: patients entering in batches;
- Difficulties in patient's transportation to OR and nurseries, since the transportation is performed in beds and corridors are narrow;
- Nursery vacancies unknown before patients arrive to hospital;
- Complex and non standardized bed attribution process;
- Delays in patient OR preparation;
- Overbooking of the OR surgical program;
- Tardiness at the beginning of the day at the OR, causing delays on the entire schedule, and leading teams to end their shifts after hours;
- Second patients arriving late to the OR, therefore delaying surgeries;
- High turnover time in the OR;
- Patients still resting in their beds after being notified of their clinical discharge;
- Lack of information regarding patient discharge.

Chapter 4

Solution Design and Implementation

4.1 Introduction

After mapping the current state and detailing the improvement opportunities found, following the VSM methodology, the future state was designed and breakthrough areas, i.e. improvement clusters, were defined. For each improvement area, specific initiatives were conceived in order to tackle the opportunities, eliminate waste and create flow in the process.

Once more the methodology was dived between the two stages of the process. In each stage the breakthrough areas were identified, as well as the improvement actions of each area.

The actual implementation was performed in the Gemba, hand in hand with the team, whose dedication was crucial to implement and sustain the improvement actions.

4.2 First Appointment and Planning stage

At this first stage of the Surgical Patient flow, the main improvement area was the reduction of Appointment cancellations, i.e., cancellations of Group Appointments, Anesthesia Appointments, etc., which may ultimately lead to cancellations and reschedules of surgeries. Every time a surgery or an appointment is cancelled, hospital staff is incurring in rework which is nothing more than pure waste. Moreover, reschedules and cancellations deeply affect the patient's experience, as well as staff and equipment preparation.

Concerning implementation, the Digestives clinic was used as an experimental pilot.

4.2.1 Reduction of Appointment cancellations

As seen in the previous chapter, the team raised many improvement opportunities related with appointments without the full patient study, which led to same day cancellations or incomplete decisions along the patient circuit. To address the issue, the patient flow was redesigned with the establishment of several check points.

4.2.1.1 Redesign of the patient flow with the implementation of check points

Regarding the redesign of the patient's circuit and once more following the VSM methodology, the team was gathered in a workshop to design the future vision, i.e., the ideal state for this stage of the surgical patient flow. The ideal state, schematized in Figure 4.1 would be for the patient to arrive for the First Surgical Appointment where he can have his exams booked. After this, the patient comes back to the hospital for his Group Appointment, where the therapeutic proposal is presented. However, before this Group Appointment, two check points were created at the secretariat, to avoid same day cancellations of Group Appointments and to prevent unnecessary trips to the hospital by the patient. Concerning the first check point, if, after the Surgical Appointment, the exams requested by the physician aren't booked, the secretariat emits an alert so that the exams can be properly scheduled by the exam department. The second check point, which is activated few days before the Group Appointment, verifies if the exams were performed and already available. If not, the secretariat doesn't allow patients to move forward to the Group Appointment, rescheduling the patient's appointment and changing the current appointment's slot to another patient, who had already all prescribed exams available. After the Group Appointment, the patient returns to the hospital for the Planning Appointment where the surgery is booked. Having completed the Planning Appointment, the patient performs the Preoperative Appointment on the same day. Finally, the patient arrives for the Anesthesia Appointment and is hospitalized, to have surgery on the next day. Once again it was established a check point, between the Preoperative Appointment and the Anesthesia Appointment, to make sure that only patients who were approved at the Preoperative Appointment could make it to the Anesthesia Appointment and to surgery.

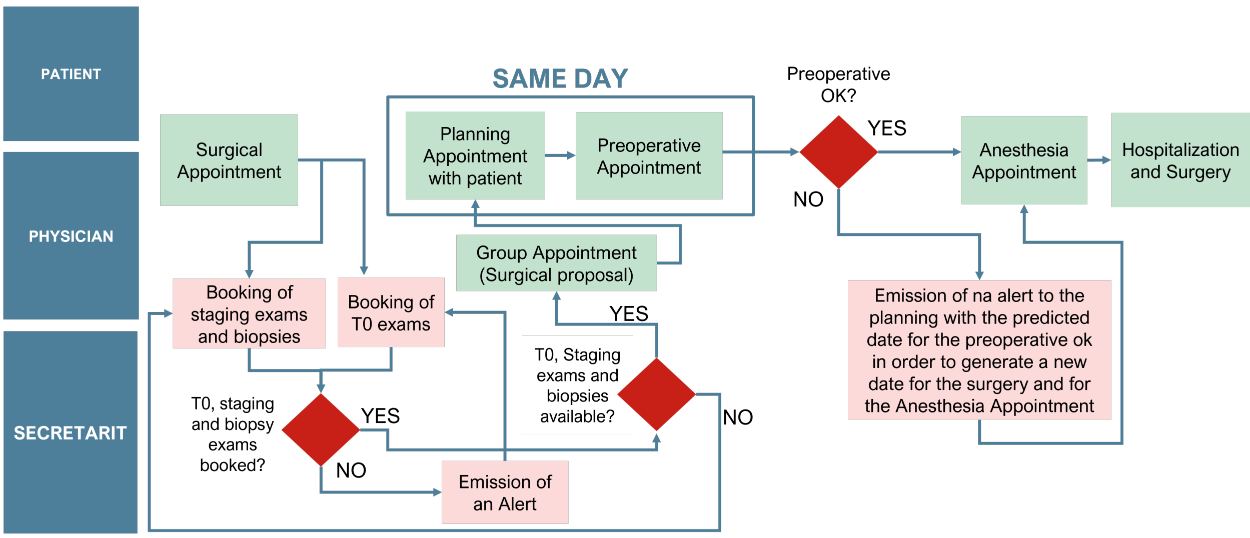

Figure 4.1: Ideal state - Surgical Patient Flow, from the first surgical appointment until hospitalization

The implementation of this redesigned process will make sure that:

- No patients arrive to the Group Appointment without the required exams to complete the patient's condition study and in consequence reduce same day cancellations and incomplete Group Appointment decisions;

- With the Group Appointment and the Preoperative Appointment on the same day, patients will have one less visit to the hospital which in this case is particularly important since IPO FG Porto's patients come from all places within the northern region of the country;

- No patients will arrive at the Anesthesia Appointment without a complete condition study and the full approval of the Preoperative Appointment, reducing once more same day cancellations of Anesthesia Appointments and even Surgeries.

4.3 Check-in, Hospitalization and Surgery stage

In the second stage of the Surgical Patient flow, the main improvement focus was the Operating Room. Once more the goal was to eliminate waste. Added value in the Operating Room of the IPO FG Porto was defined by the team as the patient being under intervention, which includes both anesthesia and surgery.

At the institution's OR two main breakthrough areas were identified, the improvement of the Operating Room start time and the reduction of the turnover time, so that the OR can spend more time adding value to its patients.

4.3.1 Improvement of the Operating Room start time

In order to improve the Operating Room start time, i.e., to reduce the time interval between the beginning of the day - 08:00 h - and the actual time the first morning patients start their anesthesia, 3 initiatives were implemented, Daily Kaizen meetings with the Nursing and the Operational Assistants teams, the redesign of the OR admission Process and Daily Kaizen meetings with the multidisciplinary operating team of each room.

4.3.1.1 Daily Kaizen - Nursing Team and Operational Assistants team

The OR nursing team and the operational assistants' team, together are made of more than 50 elements. This, allied to the challenges that an Operating Room environment presents, already discussed in Chapter 2, highlights the importance of having a formal, clear and concise moment of communication.

Daily Kaizen, with both nurses and operational assistants, was implemented to ensure the flow of information between the several team elements as well as to create a culture of constant performance evaluation supported by data. This talking with data mindset, allows to quantify the daily routine and ultimately leads to the identification of improvement actions, setting the ground rules for the establishment of a continuous improvement culture, and smoothing the implementation of other initiatives.

These daily meetings were supported by a Daily Kaizen board and took place at the beginning of every day at 08:00 h. The design of the team board involved the Nursing chief as well as several team elements. In this type of improvement action it's important that the team perceives the board as its own creation to smooth the implementation and acceptance, since some members may view daily meetings as excessive or even as a burden. The board consisted of some of the elements reviewed in Chapter 2, adapted to the particularities of these teams, and it's represented in Figure 4.2.

Figure 4.2: Daily Kaizen board with the Meeting's agenda, the KPIs and the PDCA improvement cycle

The Agenda is the schedule, describing the course of the meeting step by step, to make sure the meeting's duration was fulfilled. At Mondays, Tuesdays, Thursdays and Fridays the meetings started at 08:00 h with a maximum duration of 10 minutes and the agenda consisted of reviewing the previous day work plan, discussing its ups and downs, and aligning the present day, assimilating the work plan and raising all the alerts and important information. At Wednesdays the team's meeting, that also started at 08:00 h, had a more complete agenda with an expected duration of 30 minutes. Besides reviewing the previous and current day work plans, the team evaluated their KPIs and identified improvement actions on the PDCA cycle.

Regarding KPI's, the team identified as critical the time patients enter their assigned room, the time anesthesia begins and the time surgery begins. The team also included the turnover time, since operational assistants also attended these Daily Kaizen meetings. The team leader (the nursing chief) was responsible for gathering the KPIs and both prepare and lead the meetings. For each KPI, an objective was set as a result of discussions with both the leader and the team. Regarding the time patients enter their assigned room, the goal was established at 08:30h and

09:15h on Wednesdays - the day destined to staff meetings. As for the beginning of anesthesia and surgery, the goal was set at 08:45 h and 09.15 h respectively, and considering Wednesdays the target was 09:00 h for the beginning of anesthesia and 09:30 h for the beginning of the surgery. Finally the goal for the turnover time was set at 20 minutes. Based on these goals a green and a red zone were designed in the KPI's charts to depict, in a very visual way, the quality of the OR results. Moreover, in the patient entering the room, beginning of anesthesia and beginning of surgery KPIs, it was also represented the average values of the previous month so that the results of improvement actions were better accompanied. In Appendix C, are represented the four indicators above mentioned, in Figure C.1 there's the mean time the patient entered the procedure room, in Figure C.2 the mean time of beginning of anesthesia, in Figure C.3 the mean time of beginning of surgery and in Figure C.4 the mean turnover time, all corresponding to the period between the 3rd and the 10th January 2022. It's also important to highlight that, as time passes and improvements are consolidated and new improvement initiatives are developed, there may be the need to replace these KPIs.

The PDCA, or the improvement cycle, allowed the team to, after identifying improvement opportunities, elaborate and track the results of improvement actions.

The attendance map was left out since the number of elements of the team, doesn't allow for an efficient track of the presences.

The Work Plan, in an Operating Room context, is an element of utmost importance and as so, two boards were designed aside from the Daily Kaizen one. As illustrated in Figure 4.3, the nursing team had a work plan that described in each room which nurse is assigned to each workstation, since every room has a anesthetist nurse, a circulating nurse and instrumentalist nurse who change on a daily basis. The nurse's work plan also included information about who was responsible in the afternoon, who was assigned to emergencies, additional production, recovery room, admission and sterilization. The operational assistant's board, which is also depicted in Figure 4.3, is very similar to the nurse's board. It has the picture of every assistant to ease visualization. Each OA is assigned to a workstation and their duties are on exhibit.

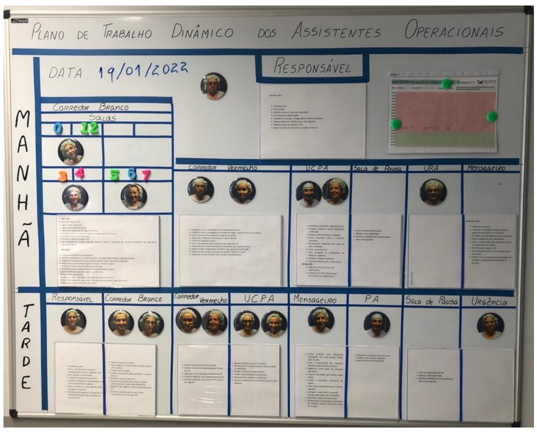

Figure 4.3: Work Plans - Nursing Team (left) and Operational Assistants (right)

To enrich the analysis of the previous day, a timeline of the OR was computed and added to the Daily Kaizen board. Figure 4.4 presents the OR surgery timeline on the 7th January 2022, with all the conventional production surgeries that happened in each room. In orange is represented the time interval between the patient's arrival to the OR until entering his assigned room. In red is characterized the time it takes until the beginning of anesthesia, after the patient arrives to the room. In light and dark green is depicted the duration of both anesthesia and surgery, respectively. It was also signalized the time at which anesthesia begins. This timeline allows to see the time spent on added value activities such as anesthesia and surgery and on the non value added ones like the admission process or the waiting for the anesthesia to start. The gap between surgeries also permits to observe the performance of the turnover as well as understand if the next patient is already in the OR when the previous procedure ends.

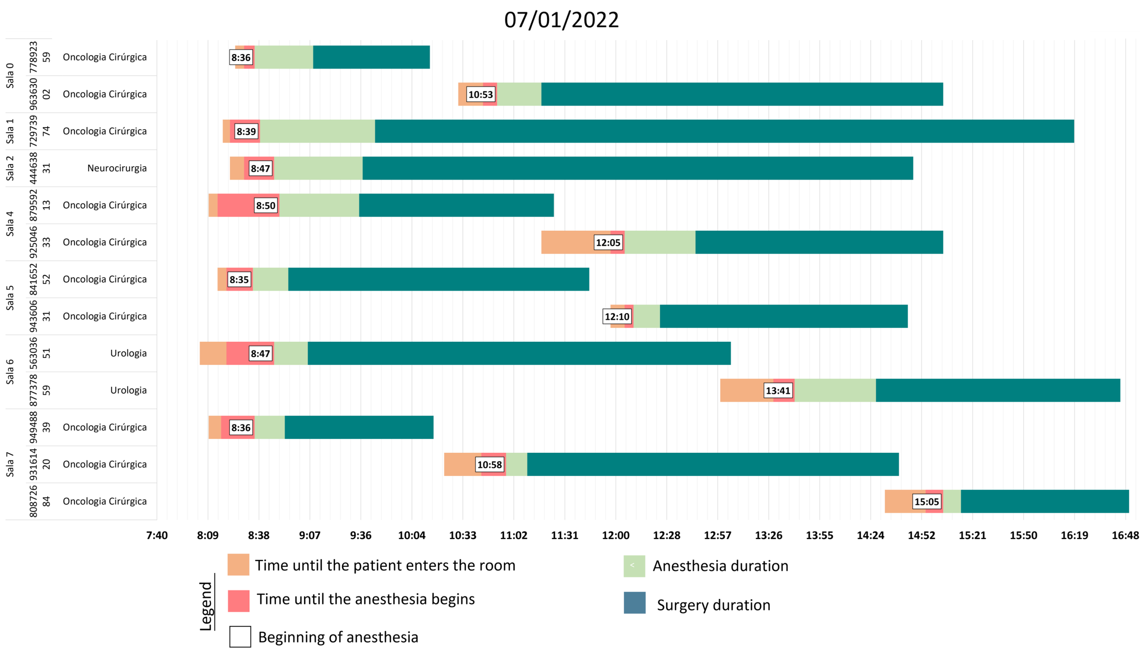

Figure 4.4: OR Surgery timeline - 7/01/2022

These tools were designed bearing in mind the importance of having visual representations, that facilitate communication and that in few seconds allow for team members to clearly understand the current situation and identify problems.

4.3.1.2 Redesigning the Operating Room admission process

As mentioned in Chapter 3, in the first surgeries of the morning, nurseries have the initiative to transport patients to the OR at around 08:00 h. This means that typically, between 08:05 h and 08:15 h there are 7 patients outside the OR door waiting to be admitted. The sooner the patients are admitted to the OR the sooner they enter their operating rooms and the sooner they initiate anesthesia and surgery. It was crucial to design an efficient admission process. The new process was designed under he premise of unit flow, i.e., process each patient at a time through the several stations that were created.

The first step was to transport patients to the OR in wheelchairs instead of beds. As mentioned in Chapter 3, patients were being transported to the OR in beds which made the transportation in the hospital corridors difficult. Moreover the OR entrance was small and with 7 beds, patients had to wait outside, in the corridors. Since most patients are physically able to be transported in wheelchairs that would facilitate the transportation process both for patients and for operational assistants who normally are in charge of this process. Then, 3 admission workstations were created: the transfer station, the data validation and the transport station. The transfer station right next to the OR entrance was assigned to one Operational Assistant whose responsibility was to change the patient from the nursery wheelchair to the OR wheelchair (due to safety protocols, nursery chairs can't enter the OR) with the help of the operational assistant from the nursery, who transported the patient to the OR. Some patient's condition requires them to be transported in beds, and when they arrive to the OR, are positioned in an gurney. The operational assistant responsible for the transfer is also in charge to transport the patient to the waiting zone. After this the OA returns to the transfer zone to process the next patient. The next station is the data validation one, assigned to 3 nurses. In this station, nurses must validate the information in the system with the patient. There are two computers at the OR's entrance, so only two nurses can work simultaneously. Once information is validated, the nurse accompanies the patient from the waiting zone to the operating room to deliver the case to the operating team. When Nurse 1 completes the validation for patient 1 and while Nurse 2 processes patient two, a third nurse can start to process patient 3. When nurse 1 returns from the operating room, computer 2 is already available since nurse 2 is accompanying patient 2 to his room. Finally, the third workstation is the transportation one, which is assigned to 3 operational assistants. Their function is to transport the patient from the waiting zone to the room, positioning him into the operating room gurney. When they finish the transportation, they are in charge of cleaning the wheelchair and transporting it to the transfer zone, so that the OA assigned to the transfer workstation can use it on the next patient. To enhance interpretation a scheme is presented in Figure 4.5.

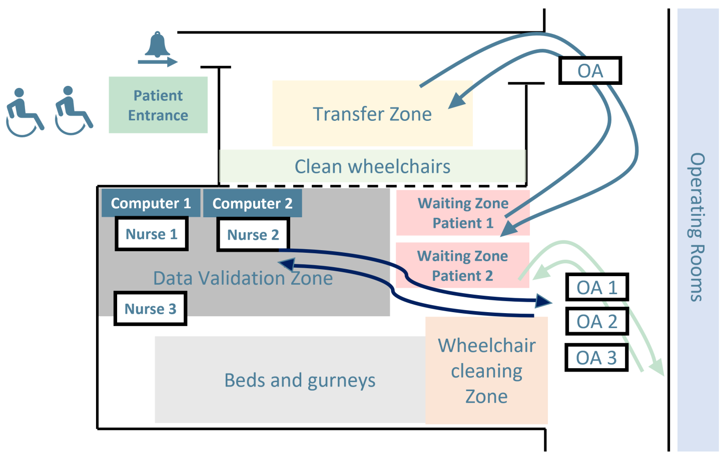

Figure 4.5: New admission process scheme

To implement this new admission process, the standardized work, with the step by step for the 3 workstations was developed and posted in the workplace, so that everyone could follow the process. The documents developed are presented in Appendix D, with Figure D.1 characterizing the transfer workstation, Figure D.2 picturing the data validation station and Figure D.3 which illustrates the transporting station.

4.3.1.3 Daily Kaizen - Multidisciplinary Room Team

During the diagnosis phase of the project, it was identified that, many times, anesthesia and surgery procedures started late because the whole surgical team - surgeon, anesthetist and the nursing team (anesthetist nurse, circulating nurse and instrumentalist nurse) - weren't present in the room at the scheduled time. Since the surgery can only start after the patient completes his anesthesia, the surgeon would arrive late at the OR, and, at the same time, since anesthesia can only start once the strategy for the surgical procedure is fully defined with the surgeon, anesthetists would also arrive late. There was the need for a formal communication moment between the whole team in order to anticipate the beginning of the procedure.

The approach followed resembles to a standard Daily Kaizen meeting but it was adapted to the context and the needs of the situation. Since anesthetists arrived late because they were waiting for the surgeons and surgeons arrived late because, besides being dependent on anesthesia, they were fulfilling their other responsibilities within the hospital (accompanying and discharging patients, prescribing medication, etc.) before arriving to the OR, the solution proposed was to perform Daily Kaizen in the form of a phone call with the whole team. The idea would be that the nursing team and the anesthetist arrive into the room at the scheduled time and once the patient is ready to initiate the procedure (typically at 08:25 h and 09:10 h on Wednesdays) the anesthetist would perform a phone call to the surgeon with the goal of understanding the surgical strategy and possible constraints. At the phone call they would also align the timings for the anesthesia and the surgery, so that the surgeon can arrive at the exact moment that the patient is fully prepped for incision.

The standard for this phone meeting was developed and it's pictured in Figure E.1 of Appendix E. The phone meeting shouldn't take longer than 2/3 minutes and the phone call itself was a responsibility of the Anesthetist doctor.

4.3.2 Reduction of the turnover time

The turnover time, or setup time, was previously addressed as part of the team's KPIs in Daily Kaizen, which facilitates the continuous evaluation of this metric. It represents the time interval between changing from one patient to the next and it may encompass several tasks like cleaning, patient arrival, material preparation, etc.. However, the cleaning, a responsibility of the operational assistants, is the biggest turnover time component and therefore will be the main focus of this initiative. The tool applied to reduce the setup time was SMED (Single Minute Exchange of Die).

4.3.2.1 SMED

As mentioned in Chapter 2, SMED distinguishes between internal work and external work, or in this context, distinguishes between the cleaning work that can be performed with the patient inside the operating room and the work that can only be done when the patient leaves for recovery, and its definition is to reduce the setup time, or in this case the cleaning time, to less than 10 minutes.

A workshop was conduct with several elements of the operational assistants team, where the steps of the SMED methodology were followed. The result of the workshop is presented in Figure F.1 of Appendix F.

The first step was to perform a work study through several Gemba observations, where cleanings were observed and filmed and employees' intakes were registered. As a result of the Work Study, Table 4.1 was constructed with all tasks identified as well as their duration and their classification into external or internal work.

Table 4.1: SMED Workshop - Work Study

Task	Internal or External	Duration
Remove bed linen	Internal	30 sec
Remove "clean" garbage	External	18 sec
Remove surgical bio garbage	Internal	1 min
Remove anesthesia bio garbage	Internal	48 sec
Clean gurney, positioning devices and gel pads	Internal	2 min 15sec
Remove instruments	Internal	1 min 43 sec
Remove suction machine reservoir	Internal	20 sec
Change tower's position	Internal	38 sec
Organize room	Internal	41 sec
Clean surfaces	Internal	2 min
Grab detergent	External	30 sec
Mop floor	Internal	3 min 30 sec
Clean ventilator and wires	Internal	2 min
Set gurney's position	Internal	1 min 30sec
Grab new garbage bags and reservoir	External	30 sec
Grab bed linen	External	15 sec
Place reservoir	Internal	45 sec
Place new garbage bags	External	1 min 30sec
New bed linen	Internal	1min 30sec

The times presented in the table above may differ according to the type of surgery and patient. For example a mastectomy is much easier to clean when compared to a thoracic surgery, or some patients might need more positioning devices than others.

Just by observing the Gemba and measuring the time intervals, several improvement opportunities were identified, namely:

- Operating assistants constantly leaving the room to fetch required equipment, such as detergents or plastics bags;
- A lot of time is wasted in replacing bin bags;
- A lot of time spent in cleaning and organizing cables;
- Operating assistants don't perform tasks in an systematic ordered way;
- Operating assistants only entered the room to clean after the patient had left;
- Equipment like positioning devices, platforms and even the heating equipment aren't necessary to every surgery, so they shouldn't be inside the operating room since everything inside the room must be cleaned after a surgery.

For these opportunities, the workshop team came up with specific solutions:

- Instead of removing the used bin bags and replacing them with new ones while inside the room, simply remove the bins with the used bags and place into the room new bins with already clean bags. The bags are later processed outside the room;
- Replace used cables with new sterilized ones. Organize and clean used cables outside the room, after concluding the cleaning process;
- Remove excessive items and equipment;
- Design a cleaning standard with a logical flow of activities, creating a cleaning circuit;
- Normalize rooms clearly identifying where to place items;
- Raise awareness of operating teams towards leaving rooms less chaotic.

The viability of these solutions was analysed by the group and the quick win actions (less effort and cost and more impact) were selected to be implemented, namely, remove excess equipment from the rooms, design a cleaning standard, normalize rooms and raise awareness of operating teams. This led to the second and third step of the SMED methodology which were about separating the tasks that could be performed before and after the patient left the room and about shifting the internal tasks into external ones. As so, a standard was designed, comprising the step by step of cleaning activities. Table 4.2 represents the summarized standard of activities that should be performed both by the operational assistant from the "red corridor" and by the operational assistant from the "white corridor". The actual standard developed is presented in Figure G.1 of Appendix G and it was posted on the doors that lead to the operating rooms.

Table 4.2: Cleaning Standard for the operating rooms - two OAs: one from the "red corridor" and one from the "white corridor"

Tasks performed before the patient leaves the room			
	Red Corridor		White Corridor
1	Dress protection equipment and gloves	1	Transfer patient from gurney to bed
2	Prepare detergents, new suction machine reservoir and garbage bags	2	Dress protection equipment and gloves
3	Remove surgical suction reservoir	3	Prepare cleaning material
4	Remove surgical garbage bags	4	Prepare clean bed linen
Tasks performed after the patient leaves the room			
	Red Corridor		White Corridor
1	Remove bed linen	1	Clean surfaces
2	Remove anesthesia suction reservoir	2	Clean and organize cables
3	Remove anesthesia garbage bags	3	Clean positioning devices
4	Place anesthesia suction reservoir and anesthesia garbage bags in the red corridor	4	Remove equipment that won't be used on the next surgery
5	Place used equipment and material in the red corridor	5	Place new bed linen
6	Organize the room	6	Adjust gurney's position
7	Clean floor and platforms with mop		Tasks performed after the next patient enters the room
8	Connect new anesthesia and surgical suction reservoirs		
9	Place new surgical and anesthesia garbage bags	1	Bring required material

Excess equipment, like platforms, positioning devices and heating machine was placed in the induction room and was only brought to the Operating room when necessary. Concerning the awareness of the teams towards leaving rooms less chaotic, the theme was approached in several Daily Kaizen meetings. Regarding the normalization of the rooms, cards with the item designations were placed in order to clearly identify where objects should be placed after cleaning. In Figure 4.6, it's pictured the normalization of the theatre rooms with the examples of the circulating nurse's table and the compresses' holder on the left, the platforms in the middle and, on the right, the surgical garbage.

Figure 4.6: Normalization of the rooms - identification cards: circulating nurse's table and compresses' holder (left), platforms (middle) and, the surgical garbage (right)

Chapter 5

Results

In this chapter, the results of the improvement events mentioned in chapter 4 are presented, accompanied by some of the project's conclusions. As mentioned previously, the diagnostic phase of the project took place in October 2020. Regarding implementation, the Daily Kaizen with the Nursing and Operational Assistants team begun in October 2020. The redesign of the Operating Room admission process started in October 2021 as well as the SMED workshop, which fully consolidated in December 2021. The Daily Kaizen with the multidisciplinary room teams as well as the new patient flow for the surgical appointments both initiated in January 2022.

The conditions of analysis of both the Operating Room start times and the turnover values remain the same as the ones reviewed in Chapter 3. Concerning the OR start times, Wednesdays were left out of the analysis and surgeries that started after 10:30 h were considered outliers. Regarding Turnover times, values higher than 35 minutes were discarded. Furthermore, when measuring these KPIs both mean and median values where registered.

5.1 Reduction of Appointment cancellations

Regarding this breakthrough area, it's important to remind that the improvement action was implemented as a pilot in the Digestives clinic.

5.1.1 Redesign of the patient flow with the implementation of check points

To measure the success of the redesigned patient flow and the implementation of check points, the Anesthetists (the physicians that receive the patient at the Anesthesia Appointment and contact with the patient process at the last step of the surgical patient flow), were asked to register the number of complete patient processes that arrived to the Anesthesia Appointment from the Digestives clinic, following a classification system of Ok/Not Ok. An Ok represents a patient's case that by the time of the Anesthesia Appointment had the Ok from the Preoperative Appointment (the step of the patient circuit right before the Anesthesia Appointment) without pending exams nor information. In alternative, a Not Okay is a process that arrives to the Anesthesia Appointments without the validation of the Preoperative Appointment or with the Ok of the Preoperative

Appointment but with pending exams or information. This evaluation method allows to verify the effectiveness of the checks points created in the first stage of the Surgical Patient flow.

The results are illustrated if Figure 5.1. Before the implementation of the new patient flow, data was gathered from 47 Anesthesia Appointments from the Digestives clinic between the periods of 02/11/2021 until the 15/11/2021. After the implementation, in January 2022, data was collected between the periods of 12/1/2022 until 19/1/2022 corresponding to 29 Anesthesia Appointments from the Digestives clinic. The percentage of Not Ok cases, i.e., processes that arrived to the Anesthesia Appointment without the Ok of the Preoperative Appointment or with the Ok but without all the required exams or information, decreased from 28%, before the implementation, to 21%, after the implementation, which allows to conclude about the positive impact of the new patient circuit on the Digestives clinic.

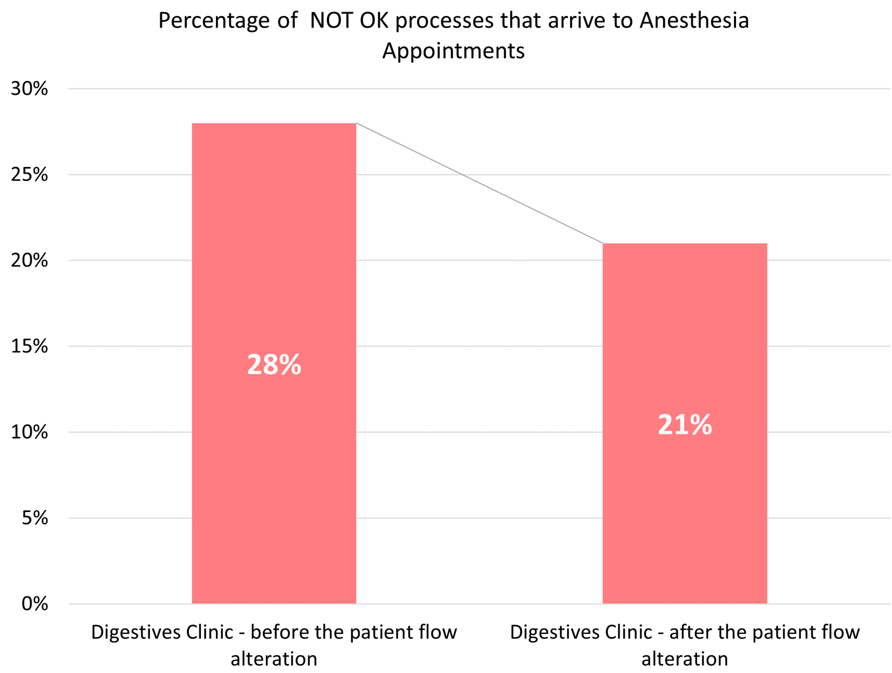

Figure 5.1: Percentage of Not Ok processes arriving to the Anesthesia Appointment before and after the implementation of the new patient flow

5.2 Improvement of the Operating Room start time

The improvement of the OR start time encompassed three actions, already explored in the previous chapter: Daily Kaizen with the Nursing and the Operational Assistants teams, Redesigning the Operating Room admission process and Daily Kaizen with the multidisciplinary room teams.

The results of the three initiatives are presented in Figure 5.2, where the mean time the patient enters the assigned operating room is represented in blue and the mean time of beginning of anesthesia and beginning of surgery are depicted in light green and grey, respectively. With Daily Kaizen at the Nursing and Operational Assistants teams, implemented in October 2020, the main goal was to achieve a culture of continuous improvement while making sure that, at the beginning of the day, all team members were aligned and focused on the same goals. After achieving this, the next step was the Redesign of the OR admission process, where the goal was to get patients to their assigned rooms earlier. This initiative launched in October 2021 and the first results were already perceptible by the end of the month with a clear decrease on the mean time patients entered the operating room. After managing to have patients entering their rooms earlier the following step was to arrange for the anesthesia to start as earlier as possible, which was tackled by the implementation of Daily Kaizen with the multidisciplinary teams at the operating rooms. In fact the initiative started in January 2022 where it can be seen a sharp decline on the light green line, the mean time of the beginning of anesthesia, causing the time of the beginning of the surgery (in grey) to decrease in consequence.

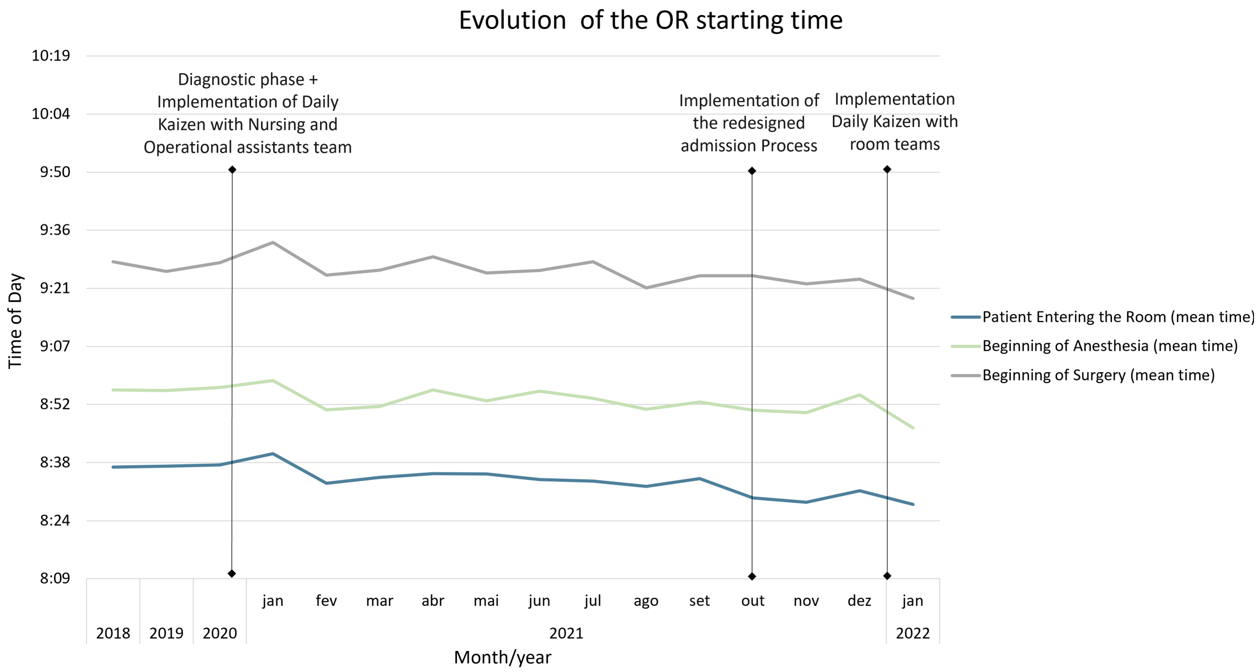

Figure 5.2: Results - Evolution of the Operating Room Starting Time

The initiative's ultimate goal was to start surgeries earlier since that's what, aside from anesthesia, really brings value to the costumer or in this case the patient (in Appendix H, Figure H.1, the evolution of the time surgeries begin is characterized and the improvements are clear). The summarized results are presented in Table 5.1, where the years of 2019, 2020 and 2021 are characterized as well as January 2022, the period after implementation and consolidation of all improvement initiatives. Considering the time patient's are entering the room it's visible that in January 2022 the goal was already met and patients are entering their assigned room before 08:30 h, on average. Regarding the beginning of anesthesia and surgery the improvements resulted in a 10 minute anticipation in the beginning of the procedure, reaching the ultimate goal of this breakthrough.

Table 5.1: Mean and Median of the Operating Room start time measures over the years: OR arriving time, Patient entering the Room, beginning of anaesthesia, and the Beginning of surgery

	Before (2019)		Before (2020)		Before (2021)		Goal	After (Jan 2022)	
	Mean	Median	Mean	Median	Mean	Median		Mean	Median
Patient Entering the Room	08:37 h	08:35 h	08:37 h	08:35 h	08:33 h	08:32 h	08:30 h	08:28 h	08:27 h
Beginning of Anesthesia	08:56 h	08:55 h	08:57 h	08:55 h	08:53 h	08.52 h	08:45 h	08:47 h	08:47 h
Beginning of Surgery	09:25 h	09:25 h	09:27 h	09.27 h	09:26 h	09:26 h	09:15h	09:18h	09:18h

5.3 Reduction of the turnover time

Addressing the reduction of the turnover time, Figure 5.3 depicts the evolution of the KPI. It's important to highlight, once more, that the increase in turnover time in 2020 corresponds to the additional hygiene and cleaning protocols in consequence of the COVID-19 pandemic. There are also some abnormal peaks presented in the chart that correspond to the vacation months, August and December, where daily routines change.

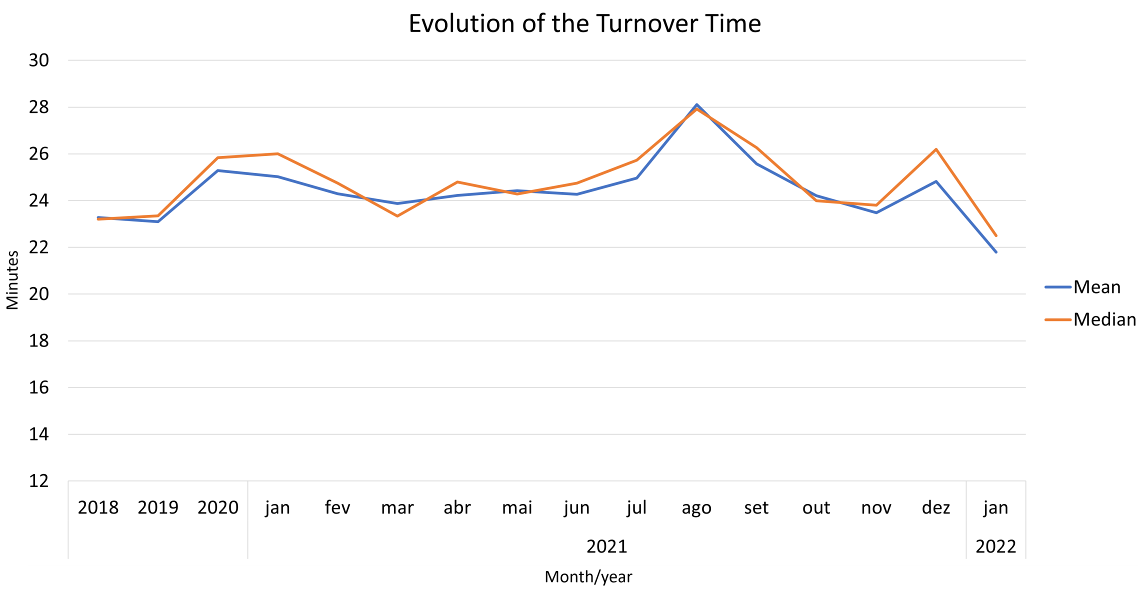

Figure 5.3: Results - Reduction of the turnover time

When comparing the results achieved, summarized in Table 5.2, with the target that was set, it's interesting to point out that even though the 20 minute turnover time goal wasn't reached, the setup time improved when compared to 2019, 2020 and even 2021. The SMED workshop, which took place in later October 2021 and fully consolidated in December 2021, allowed the OR to accomplish, in January 2022, setup times of the same magnitude of the pre-pandemic ones. Moreover, the month of January 2022, shows a mean turnover time bellow 22 minutes, a value very close to the target established.

Table 5.2: Summarized Results - Reduction of the turnover time

Before (2019)		Before (2020)		Before (2021)		Goal	After (2022)	
Mean	Median	Mean	Median	Mean	Median		Mean	Median
23,1 min	26,4 min	25,3 min	25,5 min	24,7 min	24,8 min	20 min	21,8 min	22,5 min

The difficulty of reaching this target might be explained in one hand by the complexity of cleaning protocols brought about by the COVID-19 pandemic and on the other hand by the high absenteeism rate of the OR staff, which deeply affects the turnover time, since the cleaning of each OR room requires two Operational Assistants.

5.4 Global Indicators - Efficiency and OEE

Evaluating operational KPIs, as performed in the previous sections of this Chapter, is crucial to understand and continuously monitor the day-to-day activities. However, evaluating the Operating Room's performance as a whole organism in no less important, since it allows to capture how efficiently the OR, as a scarce, expensive resource, is being utilized. To do so, and as proposed by Souza et al. (2020), the concept of the OEE was explored. In this analysis the Overall Equipment Effectiveness index, was adapted to the healthcare context - similarly to what was presented by the authors, the Operating Room Effectiveness - encompassing 3 indexes: quality, performance and availability, as demonstrated in Equation 5.1. In theory, it was established how these 3 indexes should be computed.

$$\text{OEE} = \%\text{Availability} \times \%\text{Performance} \times \%\text{Quality} \tag{5.1}$$

First, quality, Equation 5.2, which in this particular environment, is very complex to define and even more to accurately measure, was characterized as the ratio of total OR time dedicated to re-interventions (Anesthesia and Surgery) over the total time spent on surgeries (Anesthesia and Surgery). To calculate re-interventions it was assumed that every time a patient performed the same surgery it would be considered a quality problem and therefore a re-intervention.

$$\text{Quality} = \frac{\text{(Total Time Anesthesia + Surgery) - (Total Time Re-Interventions Anesthesia + Surgery)}}{\text{Total Time Anesthesia + Surgery}} \tag{5.2}$$

Performance, which should be computed by comparing the actual duration of the surgeries against the standard time that the procedure should take, was measured by establishing a standard time for each procedure, based on the institution's historical data - the median historical duration of each procedure's anesthesia and surgery. The performance index, Equation 5.3, was computed as the ratio between the sum of the total standard times for each procedure, divided by the total time actually spent on anesthesia and surgery.

$$\text{Performance} = \frac{\sum(\text{Total Standard Times Anesthesia + Surgery})}{\text{Total Time Anesthesia + Surgery}} \tag{5.3}$$

Considering the availability, as pictured in Equation 5.4, it was established that it should be measured by comparing the time patients are inside the operating rooms being under intervention, whether it's anesthesia or surgery, with the time the OR is functioning, in this case, from 08:00 h until 16:00 h, considering 30 minutes for planned stoppages, a total opening time of 07:30 h.

$$\text{Availability} = \frac{\text{Total Time Anesthesia + Surgery}}{\text{Total Opening time}} \tag{5.4}$$

The availability and the quality indexes are relatively easy to compute and the challenge lies in calculating the performance index. As previously mentioned, in Equation 5.3, the ideal approach would be to identify the historical median time for each procedure and then compare it to the actual time anesthesia and surgery are taking. However, in the cancer care context, surgeries are complex and the variability of their duration is huge. This makes the task of comparing historical surgery data impossible. This issue becomes clear by analysing in detail two of the most common surgeries at the IPO FG Porto. As seen in Figure 5.4, the mean duration of an excision of breast tissue in April 2019 took an average of 01:25 h to complete, while the same surgery in October 2020 had an average duration of 01:10 h, and in January 2022 the same surgery took 01:45 h to complete.

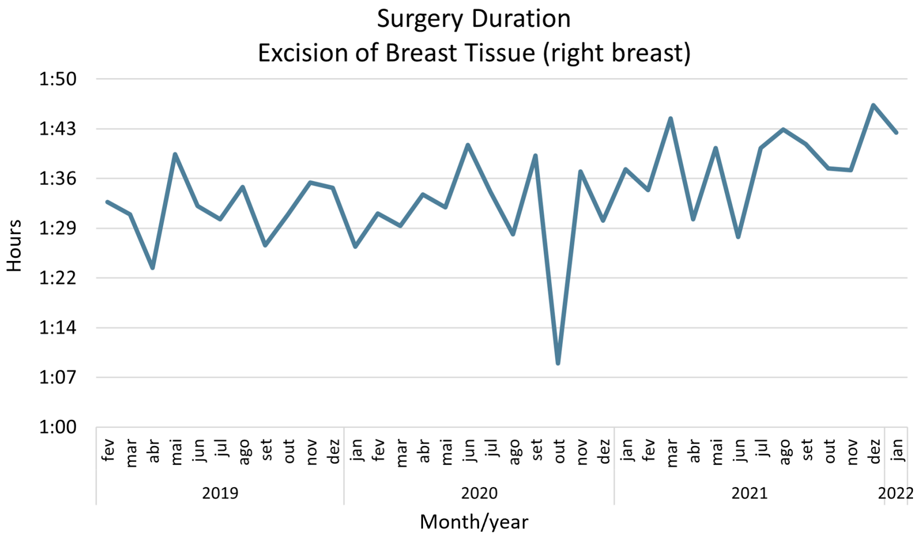

Figure 5.4: Evolution of surgery duration - Excision of Breast tissue

Studying another common procedure, Figure 5.5, a resection of the uterus, it's visible that the procedure's mean duration varied from 02:30 h to 03:30 h, in the same year (2021).

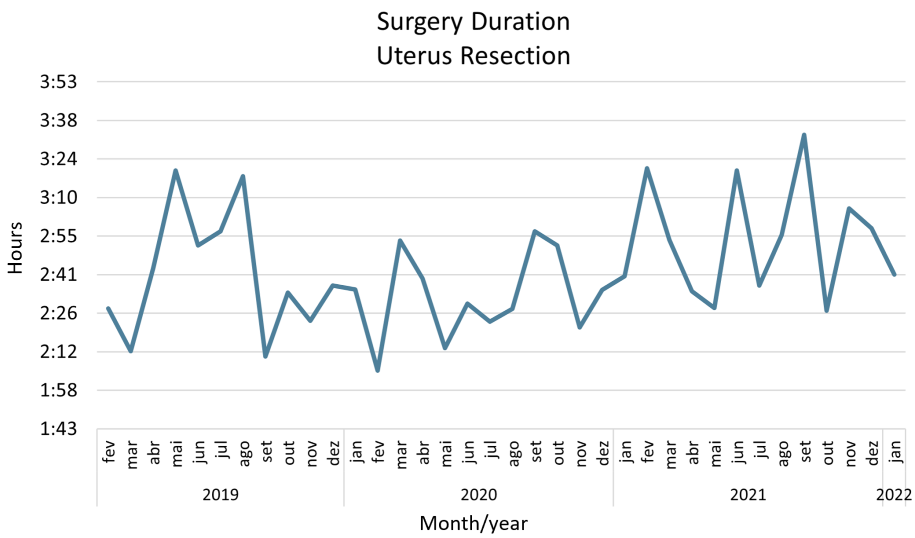

Figure 5.5: Evolution of surgery duration - Uterus Resection

These observations led to the conclusion that, at least in the surgical oncology context, this huge variability in surgery duration compromises the computation of the performance index, since calculating standard times for the procedures, based on the institution's historical data is not feasible.

Since, applying the Overall Equipment Effectiveness in the surgical oncology context isn't possible, or at least not in its original format, there's a need for another efficiency measure. Being the focus of this project, the increase of the percentage of value adding time, the OEE was adapted to the value adding definition provided by the hospital team, in accordance to the particularities of the surgical oncology context. As so, the Operating Room efficiency was computed as the proportion of total OR time spent in Anesthesia and Surgery, considering also the re-interventions. In summary, an OEE that contemplates, as expressed in Equation 5.5, both availability, in terms of time spent in anesthesia and surgery, and quality, by considering the time spent on re-interventions.

$$\text{OEE} = \frac{\text{(Total Time Anesthesia + Surgery)-(Total Time of Re-Interventions Anesthesia + Surgery)}}{\text{Total Opening time}} \tag{5.5}$$

Figure 5.6 depicts the evolution of the OR's efficiency since 2018. It's worth to point out the rise in the OEE that started in the third quarter of 2021, when the majority of the OR improvement initiatives started, namely the SMED workshop and the redesign of the Operating Room admission process. The Daily Kaizen with the nursing and operational assistants team started in the third quarter of 2020, after which the KPI also increased. In January 2022 with the implementation of the Daily Kaizen with the room teams, the OEE was around 72%.

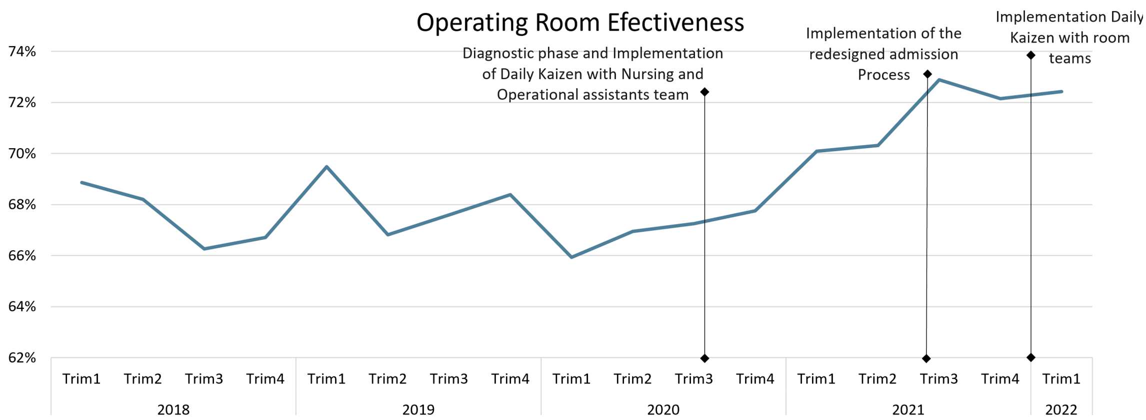

Figure 5.6: Operating Room Effectiveness adapted do the surgical oncology context

However, many factors may influence this KPI. For example, if surgeries are taking more time, logistical complexity will be smaller, due to less turnovers, and therefore teams will spend more time adding value (performing anesthesia and surgery). On the other hand if the OR is using less rooms, the logistical implications will also be smaller, once again due to less change overs. Bearing this in mind, these two factors were further explored to make sure that the conclusions regarding the OEE weren't too optimistic. Figure 5.7 presents the analysis performed on the evolution of the mean duration of surgical procedures (anesthesia and surgery). When computing the mean procedure's duration, since some of the information regarding anesthesia was incorrect, the mean duration of anesthesia obtained between the periods of 2018 and 2022 - 24,3 minutes - was used as an approximation of the anesthesia duration. In fact, procedures seem to become more extent over the years, however the increase is very smooth. In the first quarter of 2019, the mean duration of surgical procedures was at 02:35 h, while in the same period of 2021, the value was at 02:45 h, an increase of only 10 minutes. When looking at the first quarter of 2022, there's a low on the average surgery duration that reached the 02:38 h, proving that the increase in efficiency, in this period, wasn't accompanied by an increase in the mean surgery duration.

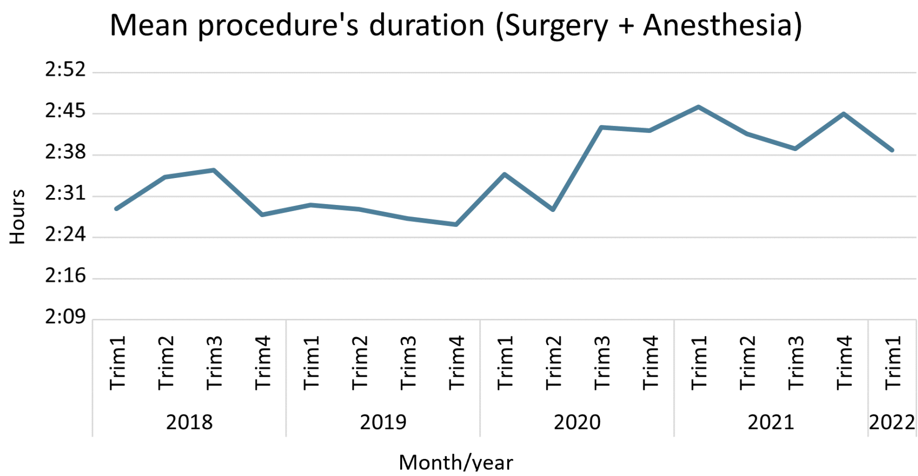

Figure 5.7: Factors that Influence the proportion of added value time: procedure's duration

Regarding the number of utilized rooms, presented in Figure 5.8, the peaks seem to be constant over the years, probably due to vacation periods, as observed when comparing the third quarter values. In January 2022, the rooms were being used at its fullest, 7, which means that the OR was running at the maximum logistical complexity.

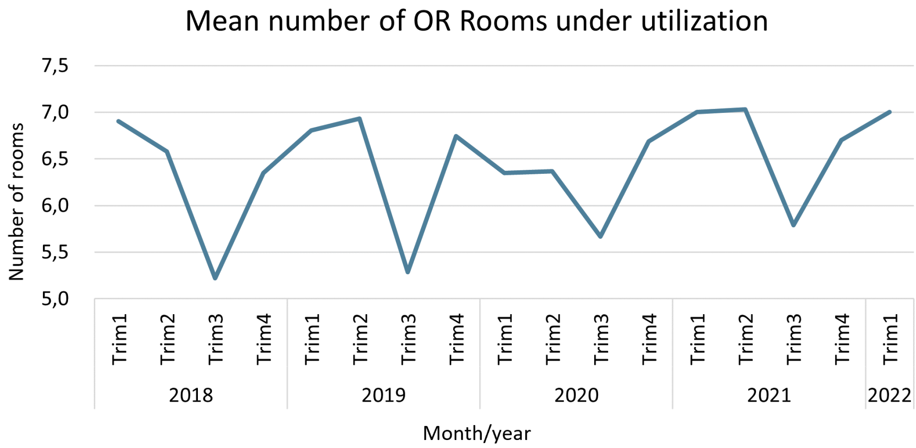

Figure 5.8: Factors that Influence the proportion of added value time: number of utilized rooms

So, even though the average surgery duration seems to be increasing, at a steady and low rate there was an exception in January 2022 with a clear decrease in the mean procedure's duration. Furthermore, in this period, the OR was also running with it's full capacity, 7 rooms. This proves that the improvement measures implemented have positively impacted the OEE and the OR's efficiency, without the influence of factors like surgery duration and the number of rooms being under utilization.

Moreover, in Figure 5.9, the total OR time spent on anesthesia and surgery was analyzed, disregarding the quality index and re-interventions. It's clear the impact done by the COVID-19 pandemic which caused a decrease in the percentage of value adding time between 2019 and 2020. When looking at 2021 and even 2022, the increase reaches the 5.4 percentage points, which corresponds to a gain of 2.8 OR hours, when considering the 7 rooms available. This gain is explained by the improvements implemented in this project.

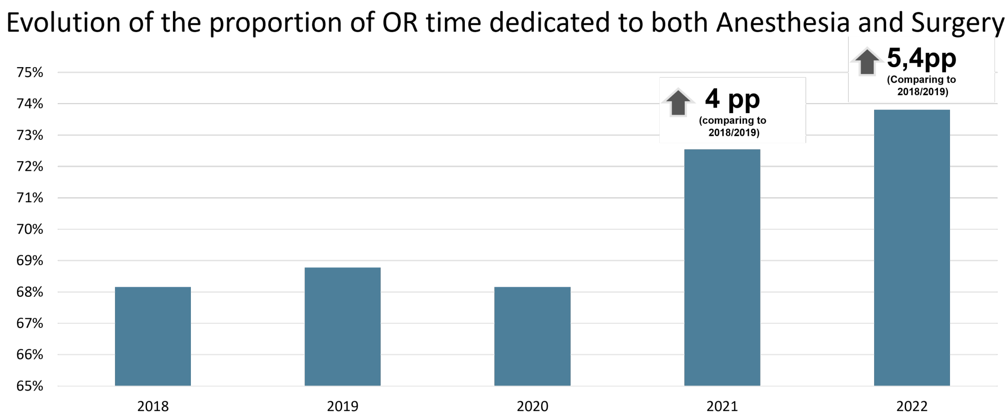

Figure 5.9: Evolution of the OR's value adding time (Anesthesia and Surgery)

5.5 Benchmarking

In Chapter 2 it was highlighted the importance of Benchmarking in order to pursue the journey of continuous improvement. As so, daily operational data - turnover time, mean time patient enters the room and beginning of anesthesia - was collected from several institutions where Kaizen Institute worked or is currently working. The sample is made up of 5 public hospitals and 2 private ones. The public hospitals belong to the categories B,C,D and E, a classification given by the NHS accordingly to the hospital's location, size, services available, and level of specialization. IPO FG Porto, as a cancer care hospital, who offers specialized services in the oncology area, is classified as a Group F Institution. The data collected is available in Appendix I, Table I.1. Since every OR started its activity at 08:00 h, the time patients entered the room and the beginning of anesthesia were registered as a time interval, i.e., the actual time of day patients entered the room and begun their anesthesia minus the time the OR opened doors - 08:00 h. Table I.1. also includes some information about the institutions, namely the number of rooms of their central OR which helps to understand their magnitude. Hospitals where Kaizen Institute had information regarding the status of the OR before and after the implementation were considered as two independent institutions.

After the data collection, information was compiled in order to be presented in the format of value curves. In Appendix I, in Tables I.2 and I.3, are presented the calculations that made possible the construction of the before and after implementation curves. It was computed the average and the percentile 90 and 10 of all institutions, with the exception of IPO FG Porto, since the goal was to compare the organization against its Industry equals. The percentile 90 and 10 allowed to exclude from the analysis possible outliers, by disregarding values that are better than the 90% of all registers and values that are are worse than the 10%.

The actual value curves, which intend to compare, in a visual way, the organization against its industry peers, both before and after Kaizen Institute's Implementation Project are presented in Figure 5.10 and Figure 5.11, respectively.

The IPO FG Porto's value curves before KI's implementation project, presented in Figure 5.10, show that, regarding the mean time patients enter the assigned room, the institution was doing worse than the other hospitals' average and thus the red color. The distance towards the average is given by the thickness of the red curve, which is very small, and, regarding the best and worst institutions, the distance towards them is presented by the lower and higher extremity of the curve, respectively. The same reasoning applies to the mean time of beginning of anesthesia curve, where it can be seen that IPO FG Porto was one of the worst institutions considered in the analysis, being very close to the upper extremity of the curve. The mean turnover time shows that the hospital, considering the green color, was performing better than the average. However, this KPI could still be improved given the distance towards the lower extremity of the curve, which rests at 20 minutes, the percentile 10%.

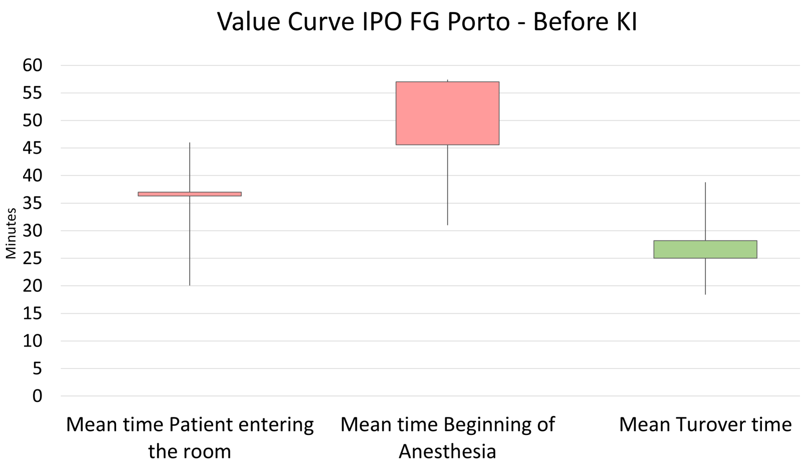

Figure 5.10: Value Curve - Before KI Implementation

Analysing the curves after the project's implementation, Figure 5.11, the improvements are clear. Concerning the mean time the patients are entering the rooms, IPO FG Porto is now better than its peers' average even though there's still a long journey towards reaching the figures presented by the best institution, around 20 minutes (08:20 h). Reviewing the mean time of beginning of anesthesia, the improvements were huge as well. Even though the hospital is still performing worse than the Industry average, IPO FG Porto is no longer the worst among its peers and the distance towards the average reduced significantly. Finally, when looking at the mean turnover time, the hospital managed to stay better than the average, and the distance towards the percentile 10%, the best hospital, shortened, as it can be seen by the thickness of the green curve, which increased.

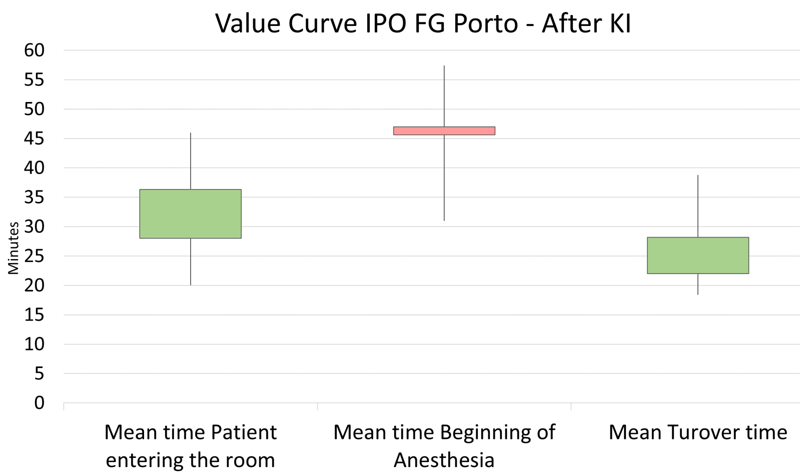

Figure 5.11: Value Curve - After KI Implementation

5.6 Conclusion

In conclusion, the results presented in this chapter are a good barometer of the success of this improvement project and fulfill the objectives established in Chapter 1, Section 1.3, namely:

First Appointment and Planning Stage:

- The redesign of the patient flow decreased the percentage of patients from the Digestives clinic who arrived at the Anesthesia Appointment - the last step before hospitalization - without a complete study or without the approval of the Preoperative Appointment from 28% to 21%.

Check-In, Hospitalization and Surgery Stage:

- The initiatives targeting the improvement of the Operating Room start time - Daily Kaizen with the nursing and operational assistant's team, the redesign of the OR admission process and the Daily Kaizen with the multidisciplinary room team anticipated the mean time patients entered their assigned room from 08:37 h (2020) to 08:28 h, and the time anesthesia initiated from 08:57 h (2020) to 08:47 h. The time surgery begun also improved from 09:27 h (2020) to 09:18 h, an anticipation of almost 10 minutes on the beginning of the day;
- The SMED workshop which aimed at reducing the turnover time, decreased the average setup time from 25.3 minutes (2020) to 21.8 minutes (2022);
- Concerning the OR's global performance indicators, the Overall Equipment Effectiveness, in its original definition, couldn't be applied to the surgical oncology context due to the great variability of the procedure's duration throughout the years. As so, the index was adapted to consider the quality (measured in anesthesia and surgery time spent on re-interventions) and the availability (which considered the time the OR spends on adding value to its patients - time spent on anesthesia and surgery). The adapted OEE increased from 66% - the minimum value in 2020 - to 72% in 2022.
- When solely looking at the proportion of time spent in both anesthesia and surgery, in 2022, there's an increase of 5.4 percentage points when compared to 2018 and 2019, which materializes into extra 2.8 hours of OR time spent on Anesthesia and Surgery, when considering the 7 OR rooms;
- When benchmarking the institution's OR, in terms of operational KPIs, against its peers from different points of the hospital classification spectrum, it's clear the evolution attained with the implementation project. However, it's important to highlight that, IPO FG Porto is still far form the best organizations and there's still a long improvement journey ahead.

Regarding the implementation of a culture of continuous improvement, the hospital staff involved in the project managed to foster a mindset of talking with data and a philosophy of solving daily problems in a structured way.

Chapter 6

Discussion

6.1 Conclusions

This project, result of the agreement between IPO FG Porto and Kaizen Institute, targeted the optimization of the surgical patient flow, with focus on its two main phases, the First Appointment and Planning stage, where the patient has all the necessary appointments before the actual surgery and the Check-in, Hospitalization and Surgery stage, where the main focal point was the Operating Room.

Through Value Stream Mapping the patient's flow was fully characterized and its main problems and wastes identified. The solutions designed were based on Lean and Kaizen methodologies and were the starting point for the project's implementation phase. The elimination of waste and the focus on added value - defined by the team as the time spent on anesthesia and surgery - were the ultimate goal of the project.

The success of the implementation was only achieved due to the dedication of the Institution's personnel, whose involvement, ideas, critical spirit and perseverance were key in not only materializing the improvements but, most difficult of all, sustaining them.

The implemented initiatives, the redesign of the patient flow, the improvement of the Operating Room start time (through Daily Kaizen with the nursing and operational assistants team, the redesign of the OR admission process and the Daily Kaizen with the Multidisciplinary room team) and the reduction of the turnover time (with the SMED workshop) fully reached the goals proposed by the project. The percentage of patients who arrived at the Anesthesia Appointment without the complete study or without the approval of the Preoperative Appointment decreased from 28% to 21%, on the Digestives clinic. The Operating Room anticipated its beginning of the day by 10 minutes, and the turnover time reduced from an average of 25,3 minutes to 21,8 minutes. The overall efficiency of the OR was also evaluated and as a result of the project, the OEE increased from 66% to 72% as well as the proportion of OR time dedicated to Anesthesia and Surgery which rose up 5.4 percentage points, amounting up to a gain of 2.8 OR hours, when considering the 7 OR rooms. When benchmarking the Institution against its Industry equals, other

Hospitals where KI worked or is currently working, the improvements become even more clear as well as the necessity of future work.

6.2 Future Work

As seen in Chapter 5 and mentioned in the previous section, IPO FG Porto has still a lot of margin for progression. As so, some suggestions for future work are presented:

- Further efforts on sustaining and consolidating the initiatives implemented;
- Spread the pilot solution tested on the Digestives clinic (the new patient flow) to the other clinics;
- Considering the Surgical Plan, make sure its closed and available earlier and without last minute alterations;
- Regarding the Turnover time, work on the arrival of the second patients, to make sure that they are present in the OR right before the room is ready to receive them;
- Concerning the cleaning standards, develop a standard just for 1 operational assistant, given that sometimes, due to absenteeism or to schedule conflicts, there isn't the possibility of having two operational assistants cleaning one room;
- Improve and Standardize the discharging process.

6.3 Difficulties and lessons learned

In fact and as mention by Rothstein and Raval (2018), Hospitals are very complex, with a lot of hierarchical social interactions allied to very stressful environments. The IPO FG Porto was no exception, as multidisciplinary teams work side-by-side every day and conflicts emerge. This combined with the attrition caused by the COVID-19 pandemic and the rising issues that cancer care presents - with the growing number of patients and growing complexity of treatments - placed the Institution as a major challenge regarding Lean Healthcare Implementation.

However, Lean isn't an Industry-exclusive methodology and Lean Healthcare is possible and proven to be effective. Portuguese Healthcare Institutions have a long but worthy journey ahead. Their focus should be on creating value to their patients while eliminating waste and establishing a culture of continuous improvement.

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Appendix A

Organization Chart - IPO FG Porto

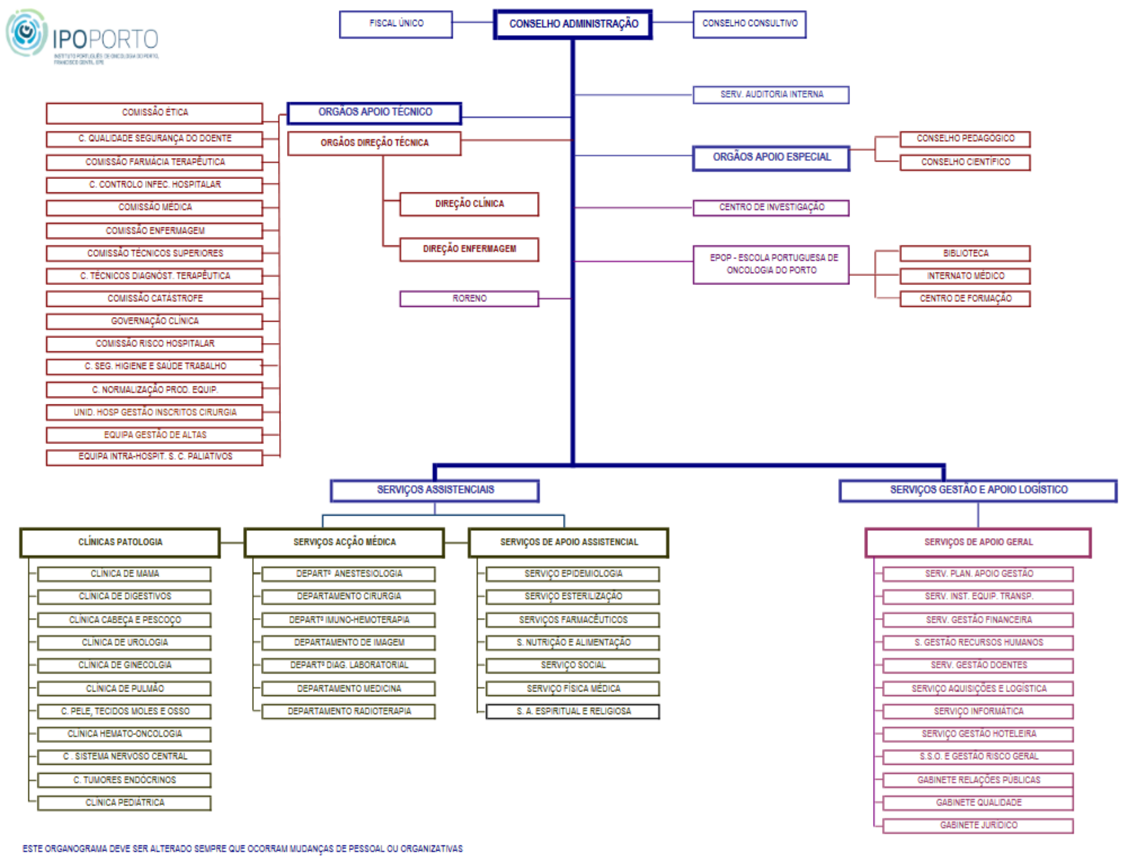


Figure A.1: Organizational Chart - IPO FG Porto

Appendix B

Surgery Cancellation

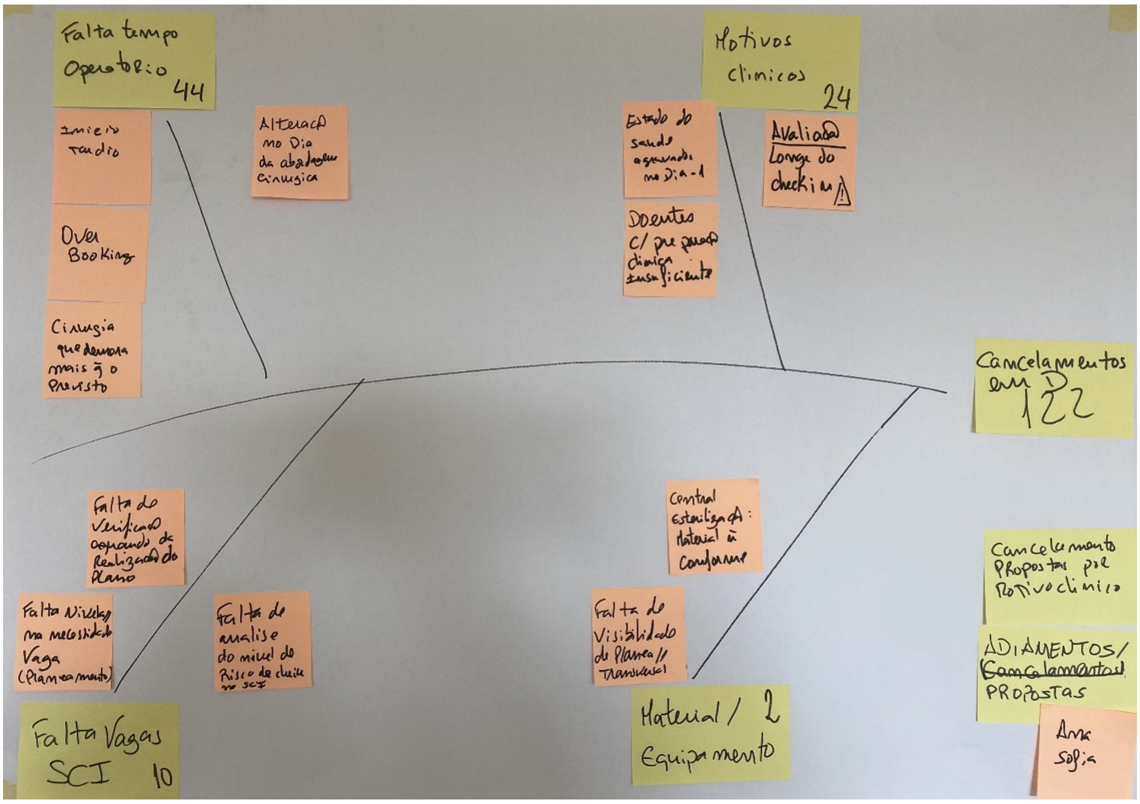


Figure B.1: Ishikawa Diagram - getting to the root cause of surgery cancellations

Appendix C

Daily Kaizen Nursing and Operational Assitants' Team - KPIs

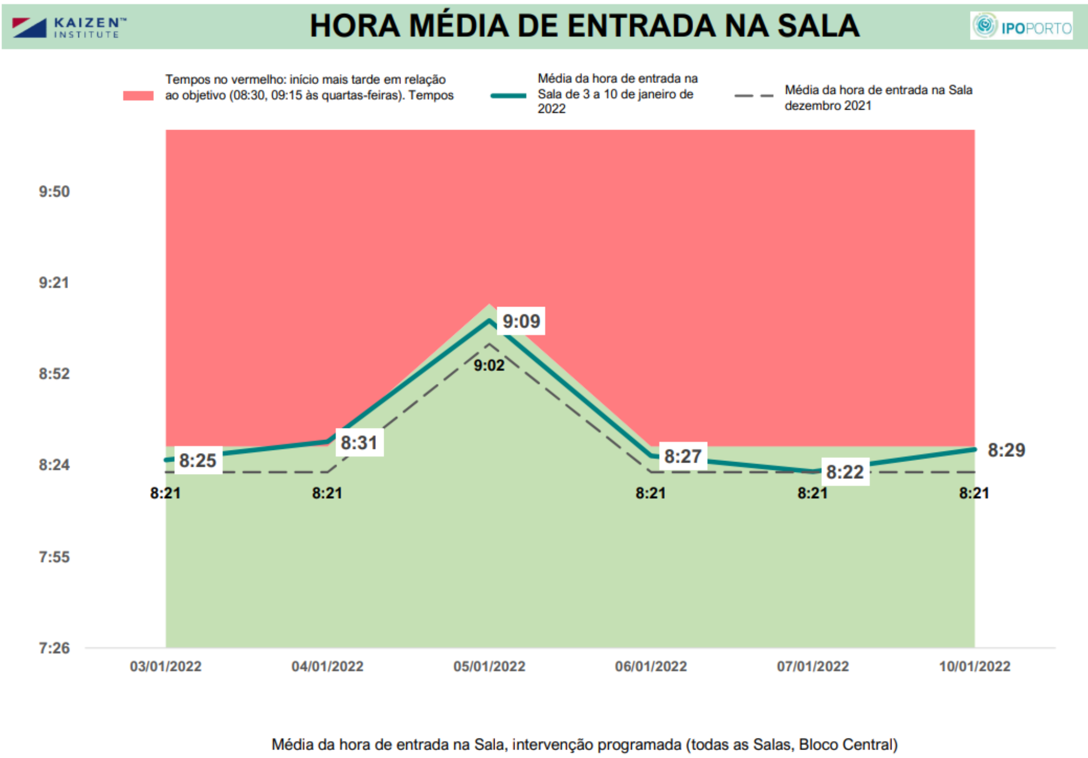


Figure C.1: Mean time of patient entering the procedure room

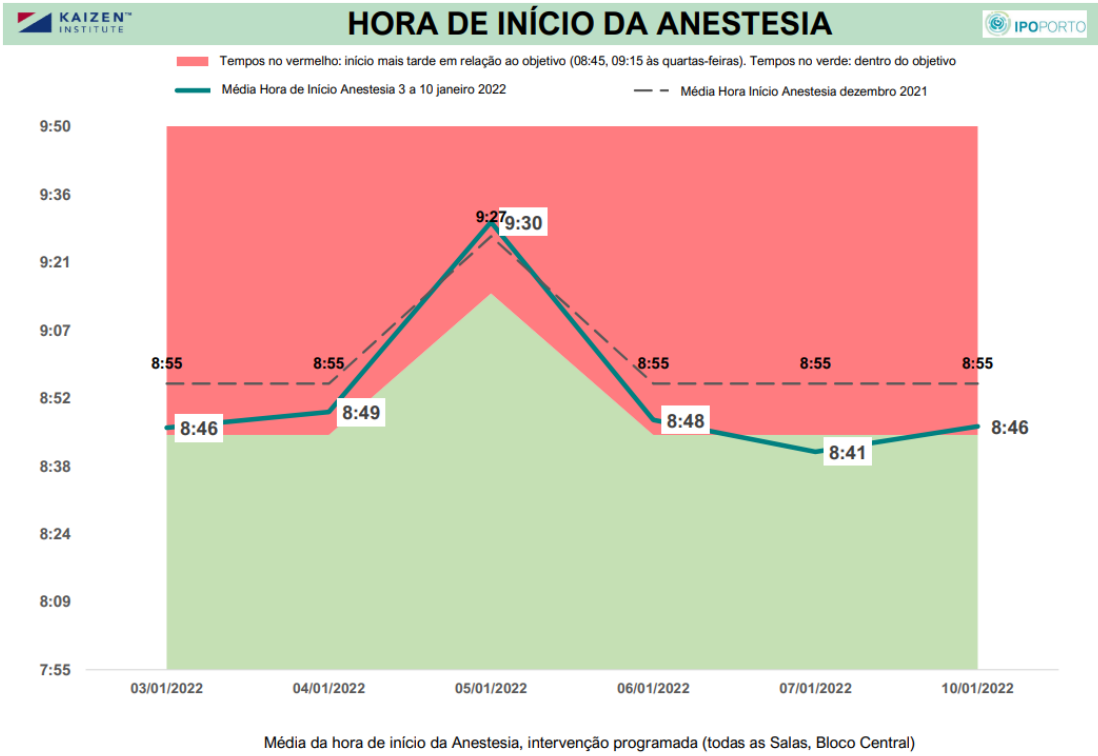


Figure C.2: Mean time of the beginning of anesthesia

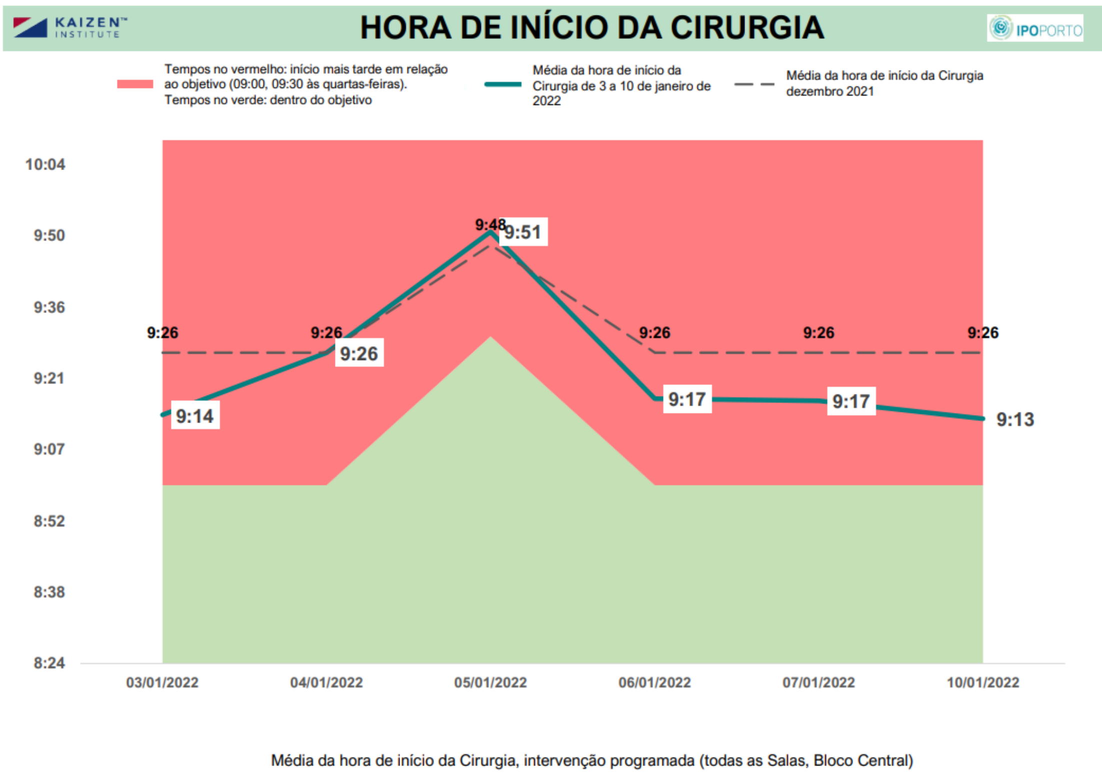


Figure C.3: Mean time of the beginning of surgery

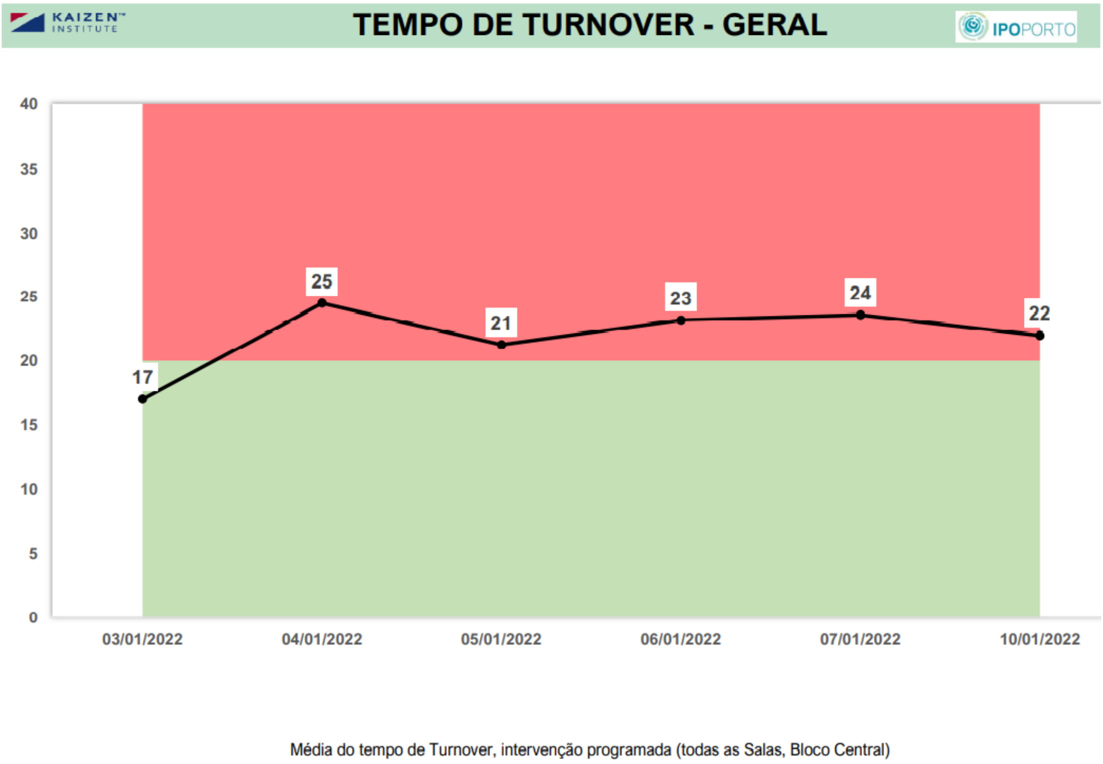


Figure C.4: Mean turnover time

Appendix D

Standardized Work - OR Admission Process

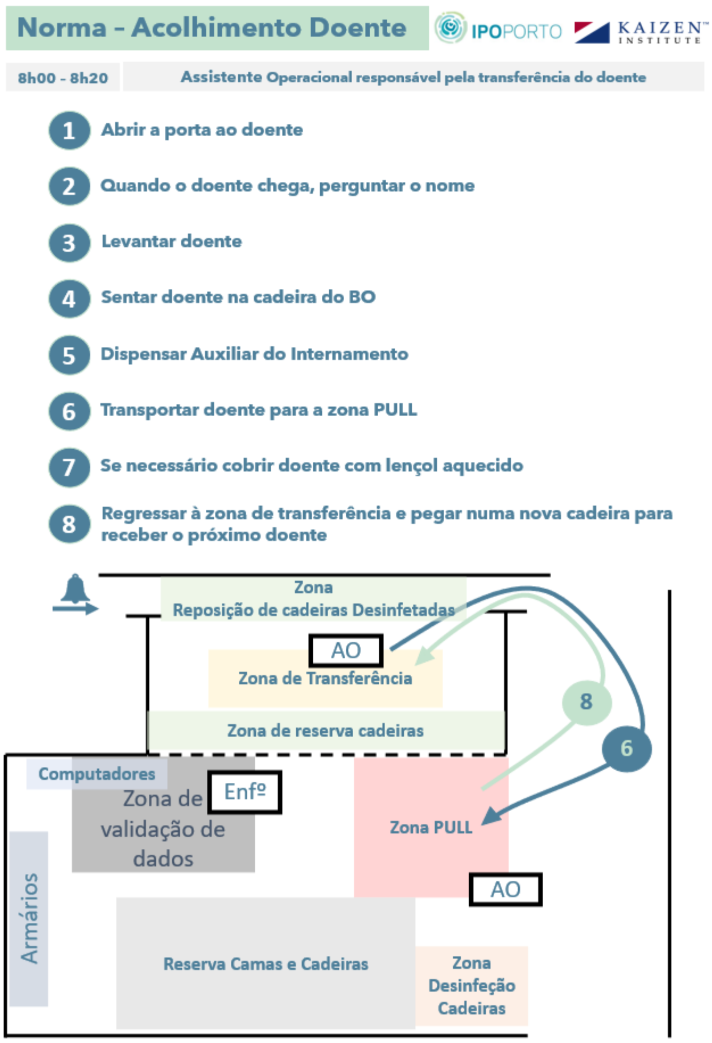


Figure D.1: Standardized Work - Transfer Workstation

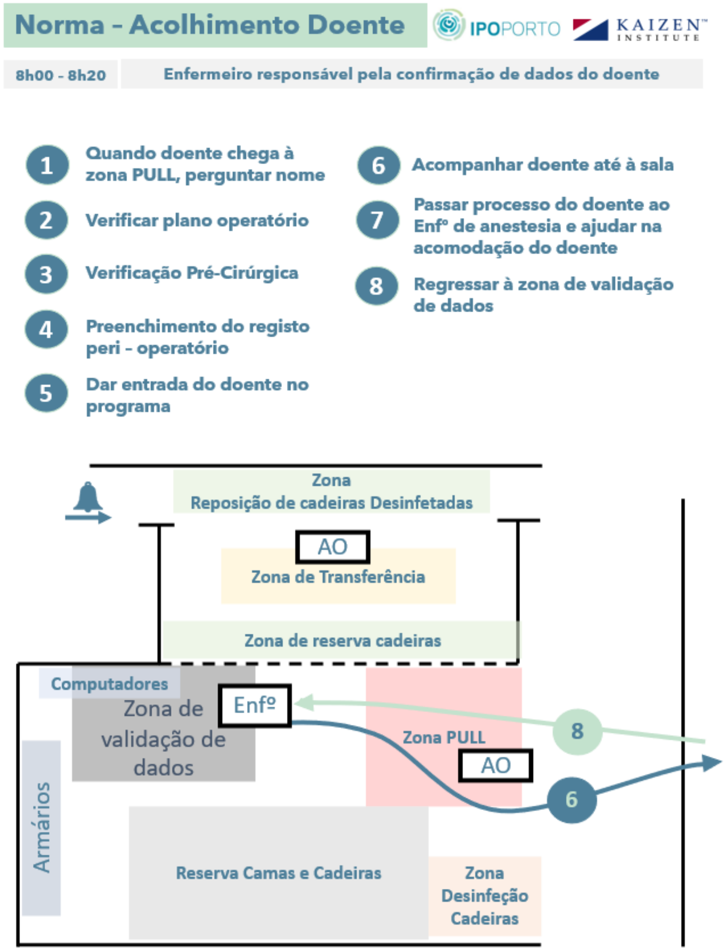


Figure D.2: Standardized Work - Data Validation Workstation

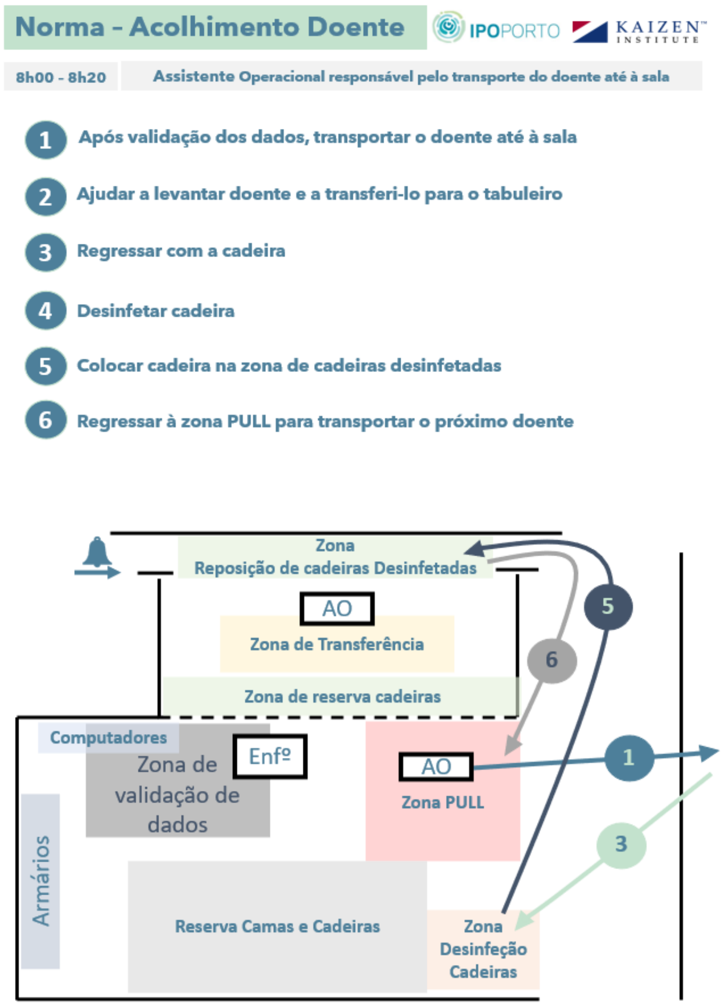
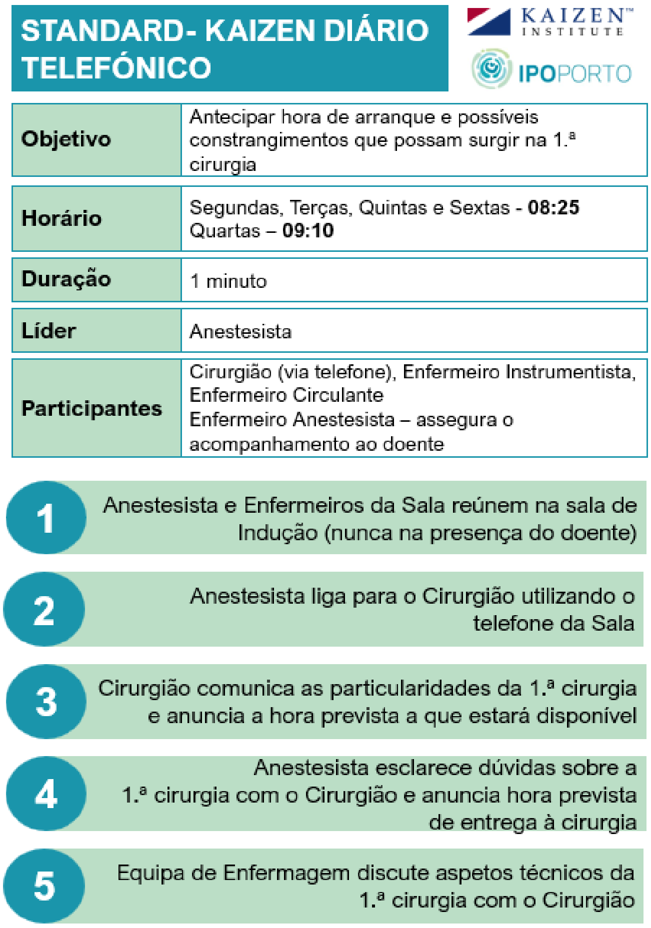


Figure D.3: Standardized Work - Transport Workstation

Appendix E

Standard Daily Kaizen - Multidisciplinary room teams



STANDARD- KAIZEN DIÁRIO TELEFÓNICO

KAIZEN™ INSTITUTE

IPOPORTO

Objetivo	Antecipar hora de arranque e possíveis constrangimentos que possam surgir na 1.ª cirurgia
Horário	Segundas, Terças, Quintas e Sextas - **08:25** Quartas – **09:10**
Duração	1 minuto
Líder	Anestesista
Participantes	Cirurgião (via telefone), Enfermeiro Instrumentista, Enfermeiro Circulante Enfermeiro Anestesista – assegura o acompanhamento ao doente

1. Anestesista e Enfermeiros da Sala reúnem na sala de Indução (nunca na presença do doente)
2. Anestesista liga para o Cirurgião utilizando o telefone da Sala
3. Cirurgião comunica as particularidades da 1.ª cirurgia e anuncia a hora prevista a que estará disponível
4. Anestesista esclarece dúvidas sobre a 1.ª cirurgia com o Cirurgião e anuncia hora prevista de entrega à cirurgia
5. Equipa de Enfermagem discute aspetos técnicos da 1.ª cirurgia com o Cirurgião

Figure E.1: Standard Daily Kaizen at the Operating Rooms

Appendix F

SMED Workshop

Figure F.1: Result of the SMED workshop with the operational assistants team

Appendix G

Cleaning Standard

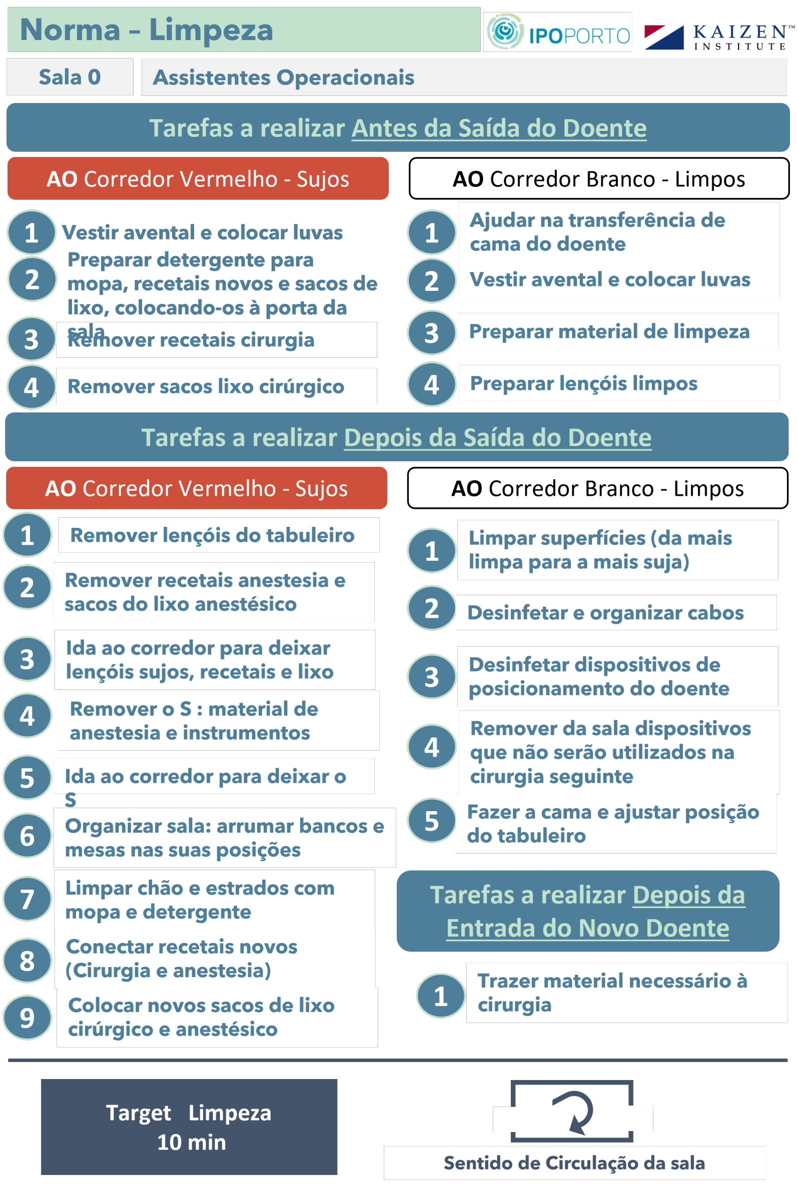


Figure G.1: Cleaning Standard for the Operating rooms

Appendix H

Evolution of the Beginning of Surgeries

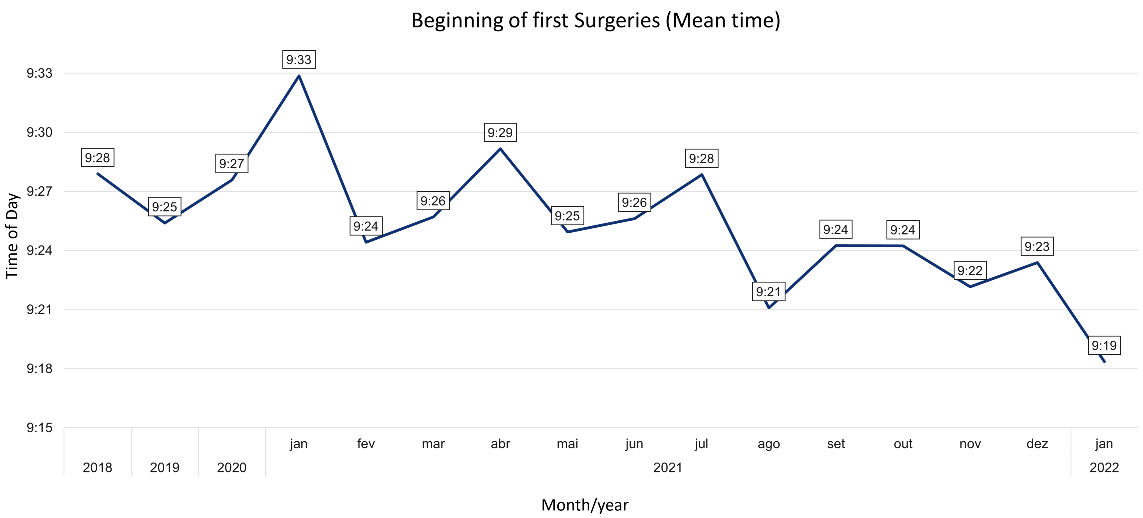


Figure H.1: Evolution of the Beginning of Surgeries (mean time)

Appendix I

Benchmarking

Table I.1: Data collected from Hospitals where Kaizen Institute worked or is currently working with. Before KI means before the implementation of Kaizen Institute's project and after KI means after Kaizen Institute's project implementation

Hospital	Category	Rooms	Turnover (Mean Time)	Patient Entering the Room (Mean Time)	Begining of Anesthesia (Mean Time)
X - Before KI	Group D	8	35 min	58 min	
X - After KI	Group D	8	27 min	35 min	59 min
Z - After KI	Group C	3	26 min	19 min	25 min
W - After KI	Group E	12	23,5 min	20,5 min	49 min
V - After KI	Group E	9	17 min	35 min	40 min
Y - Before KI	Group B	2	40 min	40 min	55 min
S - Before KI	Private	8	19 min	55 min	
R - Before KI	Private	6	38 min	28 min	
IPO FG Porto - Before KI	Group F	7	25 min	37 min	57 min
IPO FG Porto - After KI	Group F	7	22 min	28 min	47 min

Table I.2: Calculations - Value curves before KI implementation project

	Mean Value IPO FG Porto	Percentile 90%	Percentile 10%	Competitor's Average
Mean Time Patient entering the room	37 min	46 min	20,1 min	36,3 min
Mean Time beginning of Anesthesia	57 min	57,4 min	31 min	45,6 min
Mean Turnover Time	25 min	38,8 min	18,4 min	28,2 min

Table I.3: Calculations - Value curves after KI implementation project

	Mean Value IPO FG Porto	Percentile 90%	Percentile 10%	Competitor's Average
Mean Time Patient entering the room	28 min	46 min	20,1 min	36,3 min
Mean Time beginning of Anesthesia	47 min	57,4 min	31,0 min	45,6 min
Mean Turnover Time	22 min	38,4 min	18,4 min	28,2 min