

Development of a method for evaluation of internal processes in Brazilian Emergency Care Units (ECUs) through Toyota *Kata* and Single Minute Exchange of Die (SMED)

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Abstract

One of the main challenges of the health sector is to reconcile the increase in demand with the installed capacity while maintaining the quality of service. Many of the reasons that prevent a quality treatment have their origin in problems related to the flow, management, and misuse of resources. Based on the above, this article aims to present a guide to evaluating the stages to implement and manage the SMED in the health context based on the Toyota *Kata*. To achieve this objective, a base method was developed for the implementation of the aforementioned tools, through a literature review and content analysis. It is expected that this study will be able to assist in the evaluation of the waste found in the UPAs and, consequently, in its mitigation.

Keywords: Lean healthcare; SMED; Toyota *Kata*; Patient journey; Emergency Care Units.

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Desenvolvimento de um método de avaliação para processos internos de Unidades de Pronto Atendimento (UPAs) brasileiras através do Toyota *Kata* e da Troca Rápida de Ferramentas (TRF)

Resumo

Um dos principais desafios do setor de saúde é conciliar o aumento da demanda com a capacidade instalada, mantendo a qualidade do serviço. Boa parte dos motivos que impede um tratamento de qualidade tem sua origem em problemas relacionados ao fluxo, à gerência e ao mau uso de recursos. Baseado no exposto este artigo visa apresentar um guia para avaliar os estágios há implementar e gerenciar o TRF no contexto da saúde baseado no Toyota *Kata*. Para atingir esse objetivo, foi elaborado um método base para a implantação das ferramentas citadas, através da revisão da literatura e da análise de conteúdo. Espera-se que este estudo seja capaz de auxiliar na avaliação dos desperdícios encontrados nas UPAs e, conseqüentemente, em sua mitigação.

Palavras-chave: *Lean healthcare*; Troca Rápida de Ferramentas; Toyota *Kata*; Jornada do paciente; UPAs.

Desarrollo de un método para evaluación de procesos internos en Unidades de Emergencia (UEs) brasileñas por Toyota *Kata* y *Single Minute Exchange of Die* (SMED)

Resumen

Uno de los principales retos del sector salud es conciliar el aumento de la demanda con la capacidad instalada, manteniendo la calidad del servicio. Muchas de las razones que impiden un tratamiento de calidad tienen su origen en problemas relacionados con el flujo, manejo y mal uso de los recursos. Con base en lo anterior, este artículo tiene como objetivo presentar una guía para evaluar las etapas para implementar y administrar el SMED en el contexto de la salud con base en el *Kata* Toyota. Para lograr este objetivo, se desarrolló un método base para la implementación de las herramientas mencionadas, a través de una revisión bibliográfica y análisis de contenido. Se espera que este estudio pueda ayudar en la evaluación de los residuos encontrados en las UPA y, en consecuencia, en su mitigación.

Palabras clave: *Lean healthcare*; SMED; Toyota *Kata*; Jornada del paciente; Unidades de Emergencia.

Introduction

The main objective of healthcare organizations is to meet the needs and expectations of patients adequately. For this, the dedication of health professionals and managers is essential to assist them with agility, safety and respect throughout the care and treatment process (CERDEIRA, 2020).

The hospital sector faces a great challenge in reconciling the increase in demand with the installed capacity while maintaining the quality of service (LIMA; BARBOSA; SOBRINHO; CALADO; SOBRAL, 2021). Because of this, most organizations in the field are characterized by overcrowding and excessive waiting times, and delays related to this waiting time significantly increase the mortality rate of patients, in addition to making the use of available resources inefficient, to the detriment of patient and staff satisfaction (IMPROTA *et al.*, 2018). Therefore, the goal for this work is to present a guide for evaluation and implementation of SMED in the health context, based on Toyota Kata.

Individual methods can improve processes in several ways; nevertheless, they all have advantages and disadvantages, making the implementation of a strategy that combines different methodologies and tools usually the most suitable for dealing with evaluation problems (PRIORI; SAURIN, 2020). To ensure the optimization and customization of the evaluation process to the specific needs of a healthcare organization, it is important to develop a new method that encompasses the aforementioned characteristics. Furthermore, by incorporating the strengths of existing methods, a novel approach can provide exclusive insights and enhance the precision and dependability of the evaluation results. Ultimately, the creation of a new method has the potential to augment the efficiency and efficacy of the evaluation process, leading to better decision-making and improved outcomes.

In this work, the proposed method will be based on the Lean Healthcare and Toyota Kata philosophies, combined with the SMED and their respective data collection and analysis instruments.

SMED (Single Minute Exchange of Die) is a Lean Manufacturing technique to reduce set-up time or tool change in a production line. The objective is to reduce the set-up time to less than 10 minutes, that is, a tool change time in the single digits (SHINGO, 1996). Lean Manufacturing is a production philosophy that seeks to maximize the value delivered to the customer while minimizing waste and activities that do not add value. The objective is to continuously improve processes, reduce cycle time, increase quality and reduce costs (FERENHOF; CUNHA; BONAMIGO; FORCELLINI,

2018). Toyota *Kata* is a continuous improvement methodology that focuses on developing problem-solving skills at all levels of the organization (ROTHER, 2009).

In an attempt to optimize or redesign their internal processes, health organizations have created tools to promote fast and effective results without major financial losses. Because of this, this work can help such institutions by providing a process management model to be executed, with the creation of an action plan with clear goals and objectives aligned with the client's wishes, to generate value for the same (BORGES; TORRES; SANTOS; SILVA; SANTOS; CALADO, 2021).

Background

Lean Manufacturing and Lean Management

The term lean emerged from the Toyota Production System in the Japanese automobile industry, shortly after the crisis resulting from the Second World War, where the leaders of these companies were forced to seek solutions capable of reducing costs with processes (LISBOA; VASCONCELOS, 2020).

Before the popularization of this system, the traditional production strategy involved large production volumes, lots with a high number of parts, and a long waiting time between operations, which usually results in a lower quality product, as defects often remain hidden until they reach later stages of the process, or even until the product is complete (ARNHEITER; MALEYEFF, 2005).

The Toyota production model focuses on eliminating waste and activities that do not add value to the result in the eyes of the customer, delivering better results while consuming fewer resources (SHREERANGA; SATHYENDRA; RAGESH; D'SOUZA; BINU, 2020; FERENHOF; CUNHA; BONAMIGO; FORCELLINI, 2018). In this thinking, success is achieved through six principles: leadership, commitment to quality, constant innovation, exceeding expectations, challenging goals and continuous improvement (FREITAS, 2020; SLACK; BRANDON-JONES; JOHNSTON, 2018).

This system evolved into a philosophy of thinking, known as Lean Manufacturing, which encompasses five basic ideas: value, value chain, continuous flow, pull system and pursuit of perfection (CHAVES JUNIOR; TEIXEIRA; GALVÃO; ALVARELI, 2021). Lean Management is a management model based on the principles of Lean Manufacturing. The true definition of Lean Management is still debated by experts in the field of operations management (ROTTER *et al.*, 2019). The most accepted suggests that lean is an "integrated socio-technical system, whose main objective is to eliminate waste by mitigating internal, supplier and customer variability" (SHAH;

WARD, 2007, p. 792). Despite this, there is still no definite consensus in the literature (ROTTER *et al.*, 2019).

Lean Healthcare

Lean Healthcare (LH) is derived from the Lean Thinking, as a new framework focused on eliminating unnecessary or inappropriate activities from processes in the healthcare sector, and on efficiency and patient satisfaction (HALLAM; CONTRERAS, 2018; TLAPA; ZEPEDA-LUGO; TORTORELLA; BAEZ-LOPEZ; LIMON-ROMERO; ALVARADO-INIESTA; RODRIGUEZ-BORBON, 2020). The adaptation of lean concepts for the health area dates from mid-2002, from which it is more easily noticed that many of the problems found in hospitals and clinics were the same ones found in industrial areas, thus giving rise to the term (LISBOA; VASCONCELOS, 2020).

The literature identifies the application of LH as a potent strategy to reduce costs and improve outcomes, and areas, where the method has been successfully applied, including intensive care units, cardiology, surgery, gynecological oncology, colonoscopy, pathology, radiology, mental health units, eye hospitals, otolaryngology, ultrasound, organ transplantation, and clinical laboratories (TLAPA; ZEPEDA-LUGO; TORTORELLA; BAEZ-LOPEZ; LIMON-ROMERO; ALVARADO-INIESTA; RODRIGUEZ-BORBON, 2020). Research indicates that, in the United States, around 70% of hospitals use Lean Healthcare or similar strategies (SHORTELL; BLODGETT; RUNDALL; KRALOVEC, 2018).

Even though the literature related to Lean Healthcare is vast, methods for its implementation in practice are not clear regarding the composition of its stages, which makes it difficult to select the most appropriate tools, techniques and application forms for this field of operations (RÉGIS; GOHR; SANTOS, 2018; HALLAM; CONTRERAS, 2018; TLAPA; ZEPEDA-LUGO; TORTORELLA; BAEZ-LOPEZ; LIMON-ROMERO; ALVARADO-INIESTA; RODRIGUEZ-BORBON, 2020).

Although the integration between the lean methodology and the healthcare area is still relatively recent, cases in the literature report a success rate, allowing hospitals and clinics to simplify their operations and focus on the value perceived by customers, which generates better management risks and, consequently, reduces the time required for the patient's recovery (IMPROTA *et al.*, 2018).

Single-Minute Exchange of Die (SMED)

SMED is a technique originating from the Toyota Production System, focused on improving operational efficiency by reducing the set-up time of activities, which reduces errors and faster resumption of work. The production process helps to reduce the total lead-time (TROMBETA; BIEHL; MEDEIROS; SOUZA, 2020).

This technique was developed by Shingo (1985) in the book "Revolution in Manufacturing: The SMED System" to improve the processes of manufacturing companies, and proposes that the maximum set-up time be kept within a limit of 10 minutes, through the rationalization of the operators' work (ROSA; SILVA; FERREIRA; CAMPILHO, 2017).

Shingo (1985) differentiates between processes and activities (or operations); a process being a continuous flow in which raw materials become complete items, and an activity being any action performed on raw materials, intermediates or final product by man, machine or equipment. Therefore, each process is composed of a series of sequenced activities.

For the application of the SMED, it is also necessary to classify the activities that make up the processes as internal or external, defined by Guzel and Asiabi (2020) as internal activities that require the action of the machine (or process) to be stopped so that they can be performed, such as repairs or tool changes. On the other hand, external activities are those that can be carried out with the machine still in action, such as searching for the next equipment to be used (GUZEL; ASIABI, 2020). The correct separation of the two types of activity is what fundamentally contributes to the reduction of set-up times (SOUSA; SILVA; FERREIRA; PEREIRA; GOUVEIA; SILVA, 2018).

- Preliminary stages: in traditional processes, it is common for external activities to be erroneously performed as internal, which causes certain equipment to be idle for longer than necessary. The responsible person must then analyze the actual working conditions in detail to have a complete view of what happened. This analysis can be carried out through tools such as sampling, timing, video recording of the activity, and interviews with workers.
- Separation of internal and external activities: this is the most important step in performing the technique. Although most people, when asked, say that it makes no sense to stop a process to perform certain activities, they often do not realize that they exhibit this type of behavior when performing these tasks. Treating the activities of a process as external as much as possible can help reduce the total time of the process by between 30 and 50%, and separation can be aided by instruments such as lists and tables, which should always be as specific and detailed as possible.

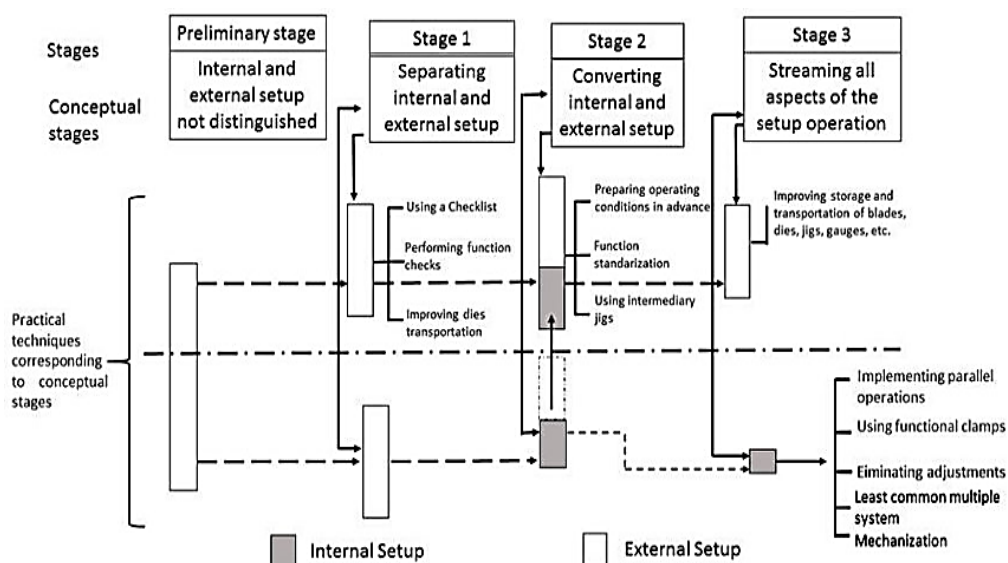
- Conversion of internal activities to external: you must then analyze the activities to determine if there are any tasks wrongly classified as internal, and define how to convert them to external. Reassessing the genuine purpose of the task often achieves it. After the analysis, tests must be carried out, and only then, the activity can be transacted externally.

In the context of health, some adaptations of concepts are necessary for the technique to make sense for the area. For example, the “unfinished product” in this case is the patient who has not yet received adequate treatment; while the “end product” is that same patient after release, healthy, after being treated (ARNHEITER; MALEYEFF, 2005). Set-up processes can be traditional machine adjustments (such as setting up an X-ray machine and sterilizing rooms for surgical procedures), or they can be directly related to the patient, such as the triage process.

SMED, despite being a technique known for its ability to optimize processes, was designed keeping in mind the particularities and needs of manufacturing companies. Because of this, not all of your guidelines may fit in other areas, such as health. Even with the extensive literature search carried out for the preparation of this work, it is necessary to emphasize that each approach must be adjusted to the area, environment, and infrastructure of the process in which it will be implemented (IMPROTA *et al.*, 2018).

Define aspects of the set-up: after implementation, the entire process must be re-evaluated to ensure that the time obtained is the minimum possible, and then standardize the new process.

Figure 1 - Stages of SMED



Source: SHINGO (1996).

Toyota Kata

Initially, Rother (2009) suggested the approach and developed it from studies on how the Toyota Company maintains its standards of continuous improvement (FERENHOF; CUNHA; BONAMIGO; FORCELLINI, 2018; SOUZA, 2020). According to Rother (2009), *Kata* is “a way of keeping two things in alignment or synchronism with a third”. The term derives from the Japanese noun, which encompasses basic forms of movement in the martial arts, passed down from master to student through generations.

The method is based on the fact that, although conditions internal and external to an organization often vary unpredictably, that same organization may have a method (*Kata*) that makes it synchronize in harmony with these conditions (ROTHER, 2009). That said, a *Kata* can be considered as a pattern of improvement that is repeated continuously, to enable people to keep their thoughts and actions in sync with dynamic and unpredictable conditions (SOUZA, 2020; ROTHER, 2009).

To achieve their ideal conditions, two types of *Kata* are used: the Coaching *Kata* and the Improvement *Kata*, defined below (SOUZA, 2020; ROTHER, 2009):

- Improvement Kata: repeated routine by which Toyota improves, adapts and evolves.
- Coaching Kata: repeated routine by which Toyota leaders teach the Improvement *Kata* to everyone in the organization.

Performed by an apprentice, the Improvement *Kata* can be used at all organizational levels. According to Souza (2020), this routine is divided into four steps:

- Understand direction: direction is the organization's ultimate long-term objective, typically selected by leadership and aligned with the company's Vision. A single Challenge (what and when) must be chosen at a time, and it must be presented clearly so that it can be defined whether it is attainable.
- Understand the current condition: one must understand the current state and obtain data to establish a desirable future condition. It is necessary to focus on what is already known, rather than performing a long and detailed analysis, and it is important that understanding is achieved through observations and measurements in the system.
- Establish the desired future condition: after understanding the current situation, it is possible to define an achievable future state in a short space of time, from a point that can be approached immediately. The Target Condition should be

more detailed and quicker to achieve than the Challenge, and once reached, it becomes the new current condition. Thus, a new Target Condition must always be established for the proposed Challenge.

- Iteration towards the Target Condition: the Apprentice and his team must run small experiments based on the scientific method and the PDCA (Plan, Do, Check, Act) cycle, to reach the Target Condition. Obstacles must be surveyed, and they must be tackled one at a time. After the end of each stage, a reflection should be made, which serves as a basis for planning the next stage.

The four steps of the Improvement *Kata* and the cycles of the Coaching *Kata* to be presented must be recorded on a board (used as a living document) called Storyboard, located as close as possible to the process and which must be visible to all involved. In organizations, knowledge waste refers to existing relevant knowledge, which is overlooked in the knowledge conversion process (FERENHOF; CUNHA; BONAMIGO; FORCELLINI, 2018).

The Coaching *Kata* routine can also be practiced by all organizational levels, as we assign a more experienced mentor (or coach) to each employee — even the coach himself — who must provide active guidance through real improvement or dealing with situations related to work (SOUZA, 2020; ROTHER, 2009).

Therefore, the Improvement *Kata* and the Coaching *Kata* work together, initially focusing on developing people's problem-solving ability, and, after that, with a relationship between learner and system, to develop the work process (SOUZA, 2020).

Value Stream Mapping (VSM)

VSM is a visual tool that allows you to schematically capture a value stream in a given process, commonly used to rearrange manufacturing systems according to a lean perspective, in a systemic or holistic way, facilitating its implementation (MAALOUF; ZADUMINSKA, 2019).

The VSM, in addition to being a valuable tool that allows the identification of waste in any process, also helps in the projection of a "future state" of how production would have to flow, from the improvement of the "current state" of a process via the principles of Lean Thinking (SEHNEM; KIPPER; SILVA; FREITAS; CHOIRE, 2020). Used to show and improve the identification in the process of all stages of product processing, are symbols, metrics and arrows.

Rother and Shook (2003) argue that the VSM implementation process is composed of five phases: product family selection, current state mapping, future state

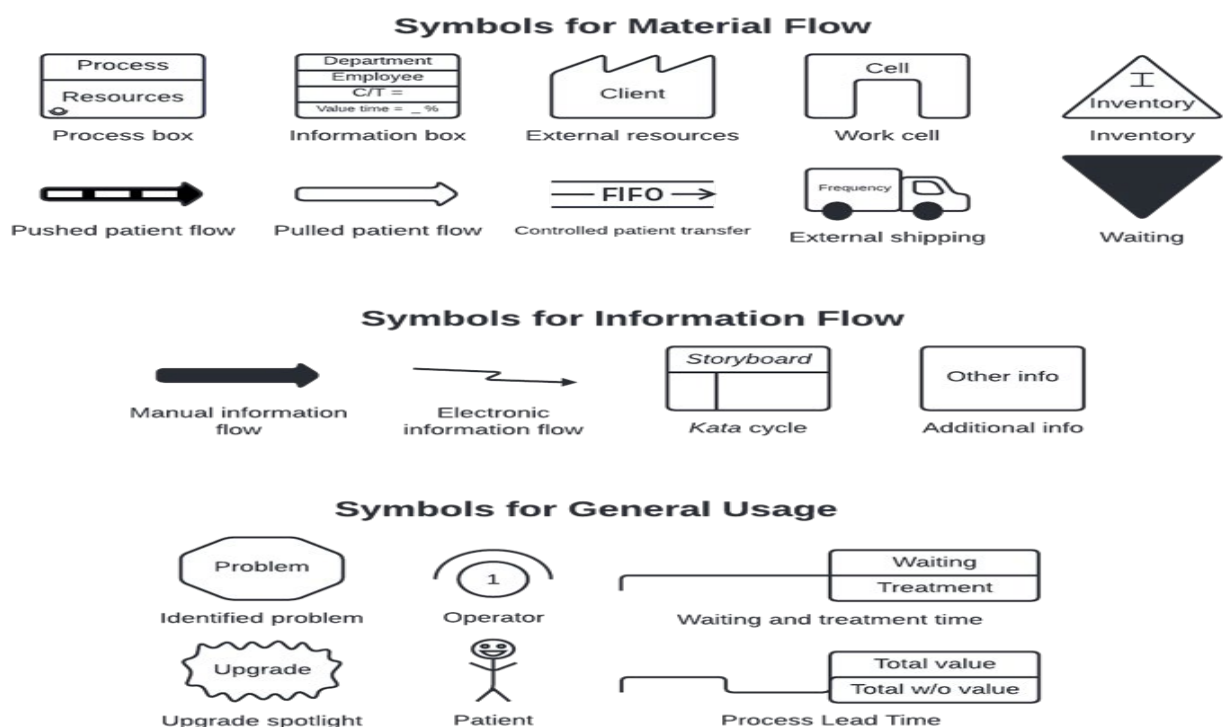
mapping, the definition of the improvement plan and implementation of improvement actions. Future state mapping defines the lean tools and techniques to be used in order to achieve such a future state (MAALOUF; ZADUMINSKA, 2019).

The Map of the current state of a process must be viewed from right to left, that is, from the customer to the supplier, to ensure that the flow is executed for the benefit of production without losses and that it is focused on adding value to the customer. The Future State Map has *kanban* cards that indicate the requisition of more material from the supplier and the *kaizen* needs that show the main improvements in important processes to achieve the desired value stream (SEHNEM; KIPPER; SILVA; FREITAS; CHOIRE, 2020).

The main objective of value stream mapping is to understand the flow of materials and information while the product follows the value stream, which makes processes clearer and allows you to see where the sources of waste are, in order to help management to make decisions focused on achieving better operating efficiency and cost reduction (SEHNEM; KIPPER; SILVA; FREITAS; CHOIRE, 2020).

To represent hospital operations better, the VSM symbology was adapted, as shown in Figure 2, with changes based on the suggestions of Sarmiento, Sanches and Santos (2018).

Figure 2 - Symbology adopted for the VSM



Source: The authors (2022) adapted of SARMENTO; SANCHES; SANTOS (2018).

Methodology

This article aims to present a guide to evaluating the stages of implementing and managing SMED in the health context based on the Toyota *Kata*. In this context, evaluation can be defined as the judgement of worth or merit of an evaluation object according to predetermined criteria (WORTHEN; SANDERS; FITZPATRICK, 1997).

To achieve the aforementioned goal, a base method was developed for the evaluation of the aforementioned tools, through a literature review proposed by Bardin (1977). It is expected that this study will assist in evaluating the waste found in the ECUs and, consequently, in its mitigation.

The framework proposed by this article is based on the one explained in March and Smith (1995), driven by the distinction between research outputs and research activities. The research activities in this study are based on the literature review presented on Ferenhof, Cunha, Bonamigo and Forcellini (2018), whereas the research outputs are based on scientific outputs or artifacts: constructs, models, methods and instantiations.

Figure 3 - Research Framework
Research Activities

		Build	Evaluate	Theorize	Justify
Research Outputs	Constructs				
	Model	xxx		xxx	xxx
	Method	xxx		xxx	xxx
	Instantiation				

Source: The authors (2022) adapted from MARCH; SMITH (1995).

Research activities were conducted based on the inquiry and judgement evaluation methods described in Worthen, Sanders and Fitzpatrick (1997). Firstly, the criteria and standards for judging quality were determined, along with if they should be relative or absolute. Then, relevant information is collected, as described in the following paragraphs of this topic. Finally, the defined standards to determine value, quality, utility, effectiveness and significance are applied to the obtained results.

For the research activities, the first step was to search keywords such as "Lean Healthcare", "Toyota *Kata*" and "SMED", to locate sources of interest with content that could be useful for the preparation of the method to be proposed in the work. The bases used for this purpose are linked to publications in the areas of management,

business, administration, service engineering and health. Among them, it is possible to list: Scopus, Web of Science, Emerald Insight, PubMed, Ebsco and Science Direct.

Non-academic sources, as well as material in languages other than Portuguese, English and Spanish, were excluded. Initially, only the titles and abstracts of the sources obtained were read to create a portfolio containing articles and theses related to the implementation of the SMED and the Toyota *Kata*, both in the health area and in different areas.

Then, the portfolio previously obtained was filtered to select the articles that would actually compose the method suggested in this work, supported by bibliographic management software. First, duplicates were eliminated, and only the method and results chapters of the remaining materials were read. After that, those that did not meet the desired criteria were discarded. Finally, a complete reading of the materials was carried out, and those deemed most interesting were selected for the preparation of the indicated guide. The criteria used for filtering are as follows:

- Does the material understand and support the SMED and Toyota *Kata* concepts correctly?
 - Does the material present a description of the method used?
 - Is SMED or Toyota *Kata* the main method used to solve the problem?
 - Does the material clearly define the problem faced and the objectives?
 - Does the material present a description of the method used?
 - Was the SMED and/or Toyota *Kata* used correctly?
 - Are the results obtained after the intervention satisfactory?
 - Does the material make clear its limitations, obstacles and unaddressed issues?

Those who best explained the interventions performed, who applied the suggested methods correctly, and who obtained satisfactory results after the changes were selected. Regarding the methods used by these materials, the selection to compose the model proposed by this work was made according to the following principles:

- Is the presented method used in the health context? If not, does the material indicate that it is possible to adapt it to other areas?
- Is the step-by-step described in an understandable way and capable of being replicated only with the guidelines present in the material?
- Are lean tools used to apply SMED or *Kata*, such as VSM and balance chart? Were these tools used correctly and in appropriate contexts?

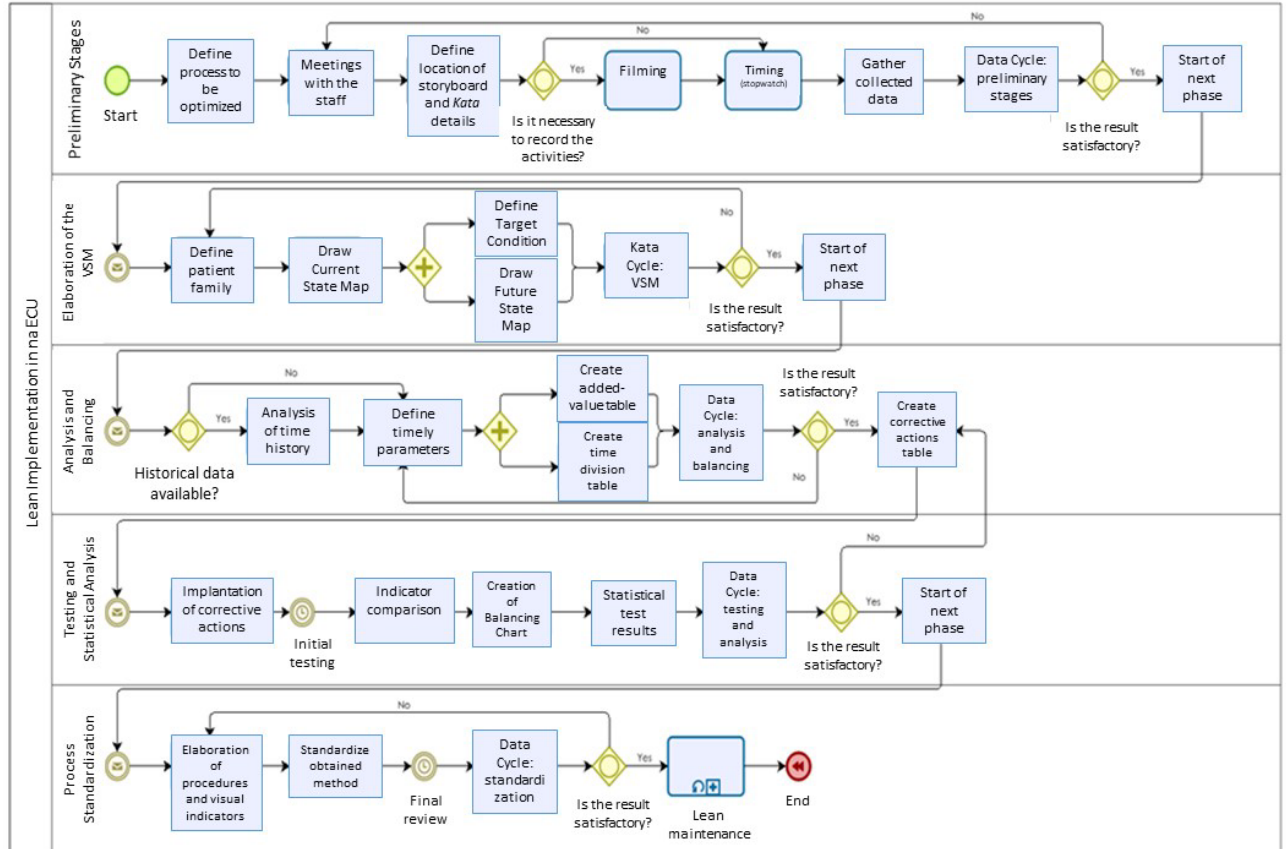
- Are the results obtained explicit, and are they presented in a clear and unambiguous way?

According to the results obtained in the research procedure, the application of the SMED is based on the work of Guzel and Asiabi (2020), Improta *et al.* (2018) and Sarmento, Sanches and Santos (2018). Issues related to the adaptation of health professionals to new practices are based on the suggestions of Cohen (2018) and Souza and Pidd (2011). Finally, the adoption of the Toyota Kata was prescribed as a tool for checking and maintaining results and continuous improvement, according to the fundamentals of Rother (2009) and the method suggested by Ferenhof, Cunha, Bonamigo and Forcellini (2018).

Results and discussions

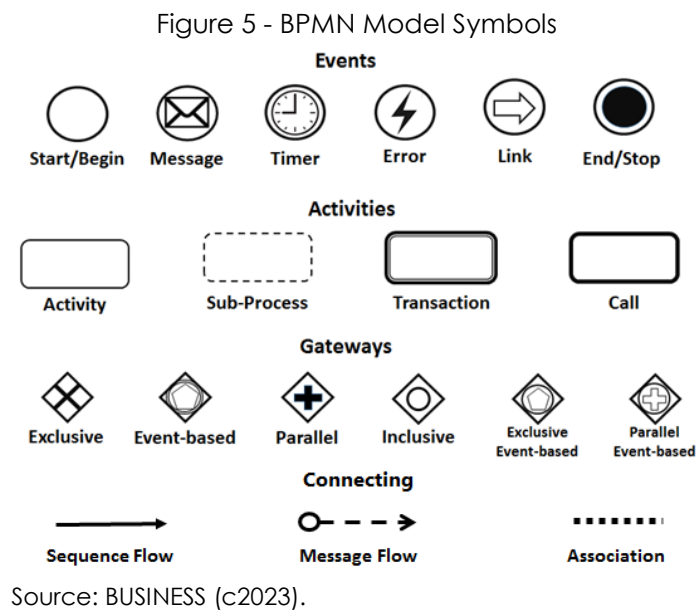
This chapter will present the results obtained through the literature review and content analysis to create and evaluate the SMED and Toyota Kata implementation method in the ECUs. The proposal is presented in the form of a flowchart, built with the aid of BPMN notation, shown in Figure 4 and described in the subtopics below.

Figure 4 - BPMN Model of Implementation Methodology



Source: The authors (2022).

Figure 5 displays the symbols utilized in BPMN.



Preliminary stages

To start implementing the proposed method, instead of using a single general approach for all the processes to be improved, each one of them should receive individual attention; therefore, the first step in adopting the new value stream is to define which of the internal processes has the greatest need for immediate attention (IMPROTA *et al.*, 2018). Then, data collection and analysis are divided into three main phases: qualitative analysis, quantitative analysis and balance sheet.

For the qualitative analysis, meetings should be held with employees involved in the hospital's processes, in order to obtain the necessary information to better understand these processes (VIEIRA, 2018). If necessary, set-up activities may be filmed so that a Value Stream Map can be drawn up that describes the patient's flow in the chosen process in full. It is important to ensure that permission to film the activities is given and to avoid filming the patients directly, unless strictly necessary, because of ethical reasons. Nonetheless, the focus of this method is to improve set-up activities, not medical procedures.

The objective of qualitative analysis is to detect bottlenecks present in operations and define which optimization approach best fits each activity. The meetings also provide information as to where the *Kata* storyboard will be located, to ensure that it will be of easy visualization and access by everyone part of the process. The periodicity of the cycles must then be defined, as well as who will be the people

who will assume the roles of Coach and Apprentice, and any other details not mentioned above.

Kata cycle implementation

At the end of each of the phases, the *Kata* cycle must be applied as a way of verifying the actions taken and ensuring that the results obtained are in line with the initial objectives, repeating the step if necessary. After the completion of the “standardizing” stage, the establishment of the Toyota *Kata* as a tool for continuous improvement begins.

In this context, *Kata* is presented as an alternative for solving problems related to the implementation and sustenance of lean over time (FERENHOF; CUNHA; BONAMIGO; FORCELLINI, 2018). In each cycle, the Apprentice is challenged by the Coach to deal with the obstacles encountered, until reaching the desired state. After reaching this state, it becomes the next starting point, and a new cycle begins.

At each cycle, the elected Apprentice must meet with the Coach, next to the Storyboard, and follow the script of questions presented in the 4-step *Kata* routine presented in the Method chapter. First, the Coach must ask the Apprentice what the target condition is, that is, what are their expectations for the end of this stage. A time interval is also established for this condition to be reached. After the end of this period, the Apprentice must report what happened and the lessons learned in the current cycle. Then, the results obtained are shared with the rest of the team, and the basis for a new *Kata* cycle is formed. Figure 6 exemplifies a way to use Storyboard to overcome challenges and provides a model for use in the healthcare field.

Figure 6 - Example of Storyboard for use in ECUS

Challenge: Lean implementation in na ECU			
Process/sector: XYZ		Apprentice: Julie	Coach: Marie
Target-Condition		Current Condition	Obstacles
Employees convinced that the Lean intervention will be beneficial to the ECU as a whole		Employees resistant to change	Employees skeptical of the effectiveness of a solution used in manufacturing for healthcare
Deadline: August 2022			
Registry of kata cycles			
What do you plan?	What do you expect?	What happened?	What have you learned?
Train employees to understand the need for change, and identify factors that limit their commitment to the intervention process	Raising awareness to the need for change and identifying inhibitors with the aim of modifying their root cause	Apprentice Team pointed out the difficulty of understanding technical terms in Japanese	The communication system between employees and their leaders is deficient and needs improvement

Source: The authors (2022) adapted from FERENHOF; CUNHA; BONAMIGO; FORCELLINI (2018).

An experienced employee, who has knowledge of the process and a relatively high hierarchical position in the ECU, must assume the Coach's role. The other employees must then form teams focused on solving the problems identified by the Coach. Different people should preferably occupy the role of the Apprentice, who is the member of the team elected to perform the *Kata* cycle with the Coach, each cycle, to stimulate the members' feeling of leadership and keep everyone involved in the process of problem solving.

Elaboration of the VSM

According to the propositions of Sarmento, Sanches and Santos (2018), considering that the process of focusing on improvements has already been defined, there are four steps necessary for the application of the Value Stream Map: defining the patient's family, drawing the state map current state, draw the future state map and develop an implementation plan.

In the first stage, it is notable that, as it is an ECU, the transformed resource is the patient (SARMENTO; SANCHES; SANTOS, 2018). Therefore, it is necessary to identify the activities through which patients transit and group them into "patient families", according to the similarity of their flow in the system. After classification, one of the categories must be chosen for flow analysis and mapping.

The second step is the design of the current state map, to visualize potential improvement points and serve as a basis for the development of a future state given the proposed changes. As explained above, information about the set-up activities carried out in the processes comes from meetings held together with employees involved in these processes, with the aid of filming if necessary. Usually, the people involved will be those who have more experience and contact with the process, to guarantee the veracity of the information (SARMENTO; SANCHES; SANTOS, 2018). Also, for greater accuracy, a few times should be collected with the use of a stopwatch.

To define the target condition, it is necessary to take into account the company's strategic objectives, the customer's needs, and the waste identified in the process. It is important that the target condition is challenging, yet realistic and achievable. To this end, it is common to use key performance indicators (KPIs) to measure progress. These KPIs can include, for example, cycle time, lead time, product quality, and inventory level, among others (SARMENTO; SANCHES; SANTOS, 2018).

For step 3, the future state map must be prepared keeping in mind the ideal state of health operations, which involves the items below (JIMMERSON, 2017):

- Defect-free delivery: exactly what the patient needs.
- No waste in the system: none of the seven health wastes should be present.
- Individual care for patients: personal contact and personalized care.
- On-demand treatment: delivered exactly as requested, when requested.
- Immediate response to problems: creates a safer environment for employees and patients, without replicas of previously recognized problems.

Analysis and balancing

Performance indicators must be used for quantitative analysis, which aims to identify the phases and waste contained in the patient's journey through direct observation. It is necessary to define parameters related to the patient's waiting time that are in accordance with the goals and strategies adopted by the ECU. These parameters can be grouped according to the patient's category previously determined in the triage. Access to a temporal data history is valuable as it can be used to assist in the measurement of parameters, if available.

For the balance sheet, the identified tasks and the phases of the operation to which they belong must be summarized in a table, containing their total time, value-adding time, non-value-adding but necessary time, and non-value-adding time (waste). The total process time must also be computed, as well as the percentage of this time that comprises activities that add value to the patient, as exemplified in Tables 1 and 2.

Table 1 - Added-value of Activities

Phase	Activity	Value-added (min)	Non value-adding (min)	Non-value-adding but necessary (min)
Triage	Triage	7		
	Waiting for exams		32	
Exams	Exams	13		
	Testing requests			44
	Waiting for results		5	
Diagnostic	Testing (laboratory)	12		
	Clinical results			60
	Results available		10	
Screening	Waiting for doctor		10	
	Doctor screening	10		
	Report writing			20
Dismissal	Waiting for dismissal		3	
	Dismissal	8		
	Dismissal reports			6

Source: The authors (2022) adapted from IMPROTA *et al.* (2018).

Table 2 - Division of the Total Process Time

Activity	Total time (min)	Value-added (%)	Non-value-adding (%)	Non-value-adding but necessary (%)
Triage	39	17,95%	82,05%	0,00%
Exams	62	20,97%	8,06%	70,97%
Diagnostics	82	14,63%	12,20%	73,17%
Screening	40	25,00%	25,00%	50,00%
Dismissal	17	47,06%	17,65%	35,29%

Source: The authors (2022) adapted from IMPROTA *et al.* (2018).

Process redesign

After determining the parameters and building the tables for analysis, the process flow redesign begins. Interventions should be based on four principles, as described by Improta *et al.* (2018):

- Standardize work and reduce ambiguity;
- Connecting interdependent people;
- Create an uninterrupted workflow;
- Allow employees to investigate problems in the process, and to develop, test, and implement measures based on a "scientific method".

A new table to illustrate the corrective actions to be taken must be created, containing the problem found, the description of the corrective action to be taken, the category (type) of action, and when its implementation process must be started, as exemplified in Table 3.

Table 3 - Corrective Actions

Problem	Intervention	Type	Start
Delays in locating patient files	Reorganize the nurses' cell	Organization	August 2022
Patients have difficulty identifying employees	Employee identification system	Visual	August 2022
Patients do not understand risk classification	Information boards	Visual	August 2022
Lack of staff at certain hours	Shift management	Flow	October 2022
Lack of stretchers	Define who needs the stretcher at the entrance, and replace its use with a wheelchair if possible	Support	November 2022
Doctors take time to collect the results of exams already available	Creating an app that notifies doctors when results are ready	Automation	November 2022

Source: The authors (2022) adapted from IMPROTA *et al.* (2018).

Testing and statistical analysis

After implementing the interventions, a statistical analysis must be carried out for the initial testing period, to compare the conditions and results of the process before and after the application of the SMED.

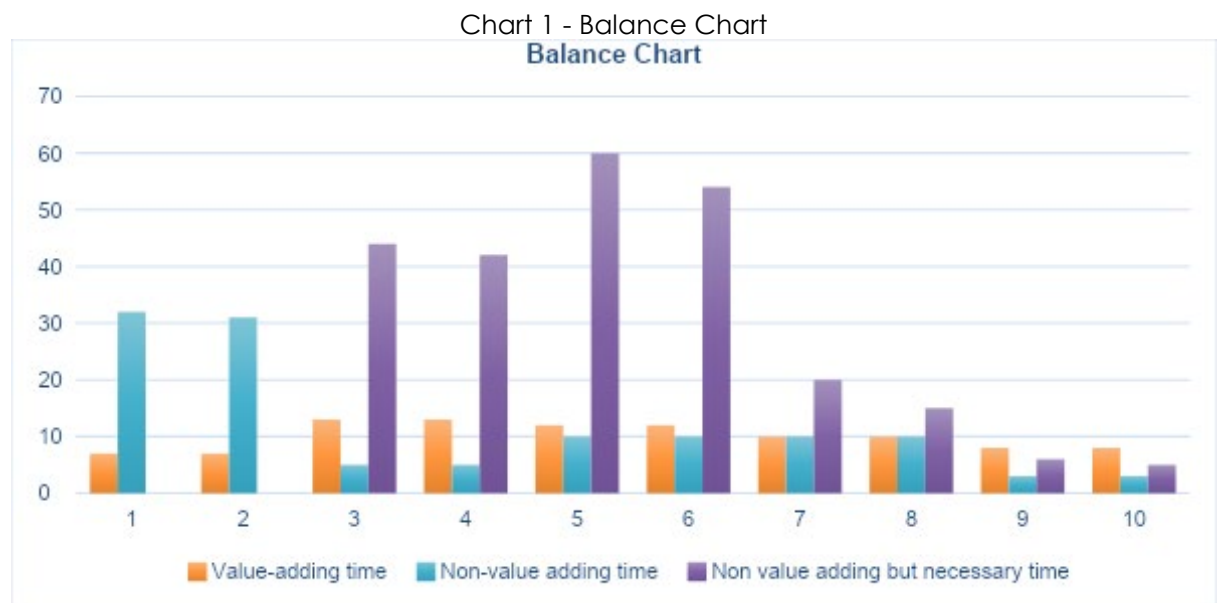
The parameters defined in the quantitative analysis must be compared in the same way, to indicate the improvements found, as illustrated in Table 4.

Table 4 - Performance Indicators Before and After Lean

Indicators	Before Lean	After Lean
Performance Indicators	Percent (%)	Percent (%)
Yellow code seen under 30min	53,6	56,9
Green code seen under 1h	52,6	54,3
Green code hospitalized with stay time below 4h	94,8	96,8
Patients hospitalized with stay time below 8h	99,8	99,8
Performance Indicators	Percent (%)	Percent (%)
Lead Time red code	72 ± 36	71 ± 30
Lead Time yellow code	151 ± 100	147 ± 67
Lead Time green code	164 ± 116	163 ± 120
Lead Time white code	160 ± 173	158 ± 156

Source: The authors (2022) adapted from IMPROTA *et al.* (2018).

Then, the balance chart referring to the value-added by the activities contained in the process in the initial and the testing stages are created to demonstrate the evolution of the value distribution of the activities, illustrated in Chart 1.



Source: The authors (2022) adapted from IMPROTA *et al.* (2018).

Finally, the results of the statistical test must be presented in a table containing the average time of the patient's stay in the hospital before and after the new procedure, exemplified in Table 5.

Table 5 - Results of the Statistical Test

Waiting time	Average time pre-Lean (min)	Average time post-Lean (min)	Difference (min)
Triage I – Triage II	25,4	23,9	1,5
Triage II – Screening	85,9	81,9	4,0
Screening – Dismissal	119,1	101,2	17,9
Triage I – Dismissal	185,3	151,8	33,5

Source: The authors (2022) adapted from IMPROTA *et al.* (2018).

The performed actions significantly reduced the time patients spent moving from phase to phase, which allowed for more time dedicated to the patient without wasting any time. As a result, the same level of service is provided with higher quality and security in a shorter time, reducing waiting times not only for the patient involved but also for others waiting.

Process standardization

After the conducted statistical analysis, if the results observed are deemed satisfactory, the new process flow should go through one last review to prepare it to be standardized.

Visual indicators and written procedures can be of help in this stage, aiding in the adaptation of current staff to the changes by being readily available to them whenever a doubt arises, so that they can solve it by themselves instead of needing a more experienced member to be at their disposal. Likewise, those indicators and procedures can also be of use to aid in the training of new staff.

Inhibitors to the implementation of lean in the healthcare industry

Despite the use of lean being increasingly common in the healthcare industry in several countries and demonstrating satisfactory success rates for improvements, many employees are still skeptical about its true applicability, because "patients are not cars, and hospitals are not 'assembly lines'" (COHEN, 2018).

Even so, the health sector needs to produce a quality "product" (in this case, clinical treatment), with the use of limited resources and through processes with a high degree of complexity, which involve multiple variables. Additionally, all aspects of

healthcare revolve around processes, which present waste that, if eliminated, would benefit both patients and employees, resulting in a safer and more efficient healthcare system. Therefore, lean is not restricted to manufacturing; its principles are universal and adaptable (GRANT, 2012).

Regarding the implementation of lean, health professionals point out some complaints. They are the following: the use of timers makes employees feel that their work is being scrutinized; concern that interventions cause layoffs; oversimplification of processes makes them tedious and repetitive, and makes employees fear being replaced by others with less capacity; difficulty in understanding Japanese terminology; and difficulty in data collection and standardization.

Lima, Barbosa, Chaves, Oliveira, Queiroz and Calado (2022) emphasize the importance of ensuring the impact of lean culture beyond the initial implementation phase, through the establishment of a Permanent Education Center (EPS), to deepen the pedagogical approach aimed at sustaining lean practices after implementation, for continuous evaluation and improvement of hospitals' internal processes.

The employees involved in the processes must understand that lean is not a set of instructions that, if followed, results in better health service; but that it is a cultural transformation that changes the way a health organization operates (TORIELLI; SMILLIE; ABRAHAMS; VOIGT, 2011). To ensure that health professionals participate in the changes, it should be taken care of that during the implementation of interventions, they feel they can make suggestions and their concerns are being heard (SANTOS; CALADO; ORLANDO FILHO; BOURGUIGNON, 2021).

Souza and Pidd (2011) suggest that, due to the inexperience of sector employees with management and engineering jargon, a standardized vocabulary should be developed to be used throughout the organization, since inconsistencies in terminology can cause serious errors due to communication failures. Using some lean terms can make it easier for employees to adapt to changes, such as "value", "continuous improvement" and "pull system".

Despite this, technical terminology in Japanese should be avoided, giving preference to short sentences that adequately convey the meaning of the replaced term. For example, instead of informing employees that a strategy will be implemented that will use *kanban* and *poka-yoke*, it can be said that the new method is based on a foolproof approach through the use of signaling cards.

Conclusion

To improve efficiency, results, customer satisfaction and safety for both patients and staff, healthcare institutions have adopted practices initially found in manufacturing industries. However, it is common that health professionals do not have experience with this type of practice, and that there is even certain disbelief in its effectiveness.

Nowadays, lean is no longer just a set of tools used for quick problem solving, but instead, a management strategy applicable to all organizations. In healthcare organizations, specifically, it is necessary to follow a defined path to implement lean. It consists of training employees and encouraging awareness of the waste contained in the processes; determining the precise sequence of activities, and eliminating those that do not add value; and improve processes through quick responses to remove waste as soon as it is identified (CHIARINI, 2014).

In this work, a new method was proposed for the evaluation of health systems with the SMED and Toyota *Kata* tools, with the main objective of reducing waiting times in hospitals and evaluating the flow of patients through the elimination of waste in the activities of set-up, following the steps in the path described above. This resulted in a significant reduction in the time patients spent moving through phases, and allowed physicians to dedicate more time to caring for the patient. As a consequence, the care process is provided with better quality and security, and in shorter time.

In an environment characterized by standardized operations, a fundamental principle shared by both the SMED and the Toyota *Kata* was the evaluation of the reduction in the occurrence of Healthcare Associated Infections (HAIs), which emphasizes the importance of systematic preparation and risk assessment in various hospital sectors (DE AMARAL; CALADO; VIEIRA; CHAVES, 2021).

The suggested model can be used regardless of the environment where it is inserted, as it only influences the concrete actions and practices to be implemented.

Finally, this research is expected to aid in the evaluation of waste detected in ECUs and, as a result, in its mitigation. Thus, results in a shorter stay of the patient in the hospital environment and in the better use of the workforce and resources of the emergency unit, making the process more organized and structured both for those who work on-site and for those who benefited from the service provided.

The limitations of this work mainly include that the data used for examples and spreadsheets are not obtained from Brazilian health institutions, and this can generate divergences due to different contexts.

As a suggestion for future research, there is a need for an in-depth study regarding the vocabulary to be used during the adoption of a lean system in health units. In addition, it is convenient to carry out a study on the research and implementation of an integral set of lean techniques and tools suitable to be used at all hierarchical levels and operations of health units, and in a way to evaluate this type of system by complete.

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