Lean Healthcare: evaluation of Single-Minute Exchange of Die and Toyota *Kata* applied in Brazilian Emergency Care Units

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Abstract
This study aimed to evaluate the implementation of the Single-Minute Exchange of Die (SMED) methodology based on the Toyota *Kata* concept in the context of emergency care units. The research methodology involved a literature review, data collection, and analysis of critical tasks in the processes of arranging hospital beds for occupancy and vacating beds. The study identified time-consuming activities and proposed interventions based on SMED principles to reduce waste and improve efficiency. The results highlighted the importance of efficient communication between nurses and the cleaning team, the parallel execution of tasks by multiple individuals, and the installation of auxiliary structures to facilitate movement and reduce travel time. The research framework provided a roadmap for implementing SMED and demonstrated its potential for optimizing health processes in emergency care units. Further research is suggested to evaluate other internal processes and analyze the overall scenario to achieve comprehensive improvements in Brazilian emergency care units. The integration of SMED and lean healthcare tools proves to be a necessary advancement in the health sector, aligning customer expectations with technological innovations and addressing new demands in the field of healthcare.
Keywords: Lean healthcare; SMED; Toyota *Kata*; Patient journey; Emergency Care Units.

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Lean Healthcare: avaliação da aplicação da Troca Rápida de Ferramentas via Toyota *Kata* em uma Unidade de Pronto Atendimento brasileira

Resumo
Este estudo teve como objetivo avaliar a implementação da metodologia Troca Rápida de Ferramentas (TRF) baseada no conceito Toyota *Kata* no contexto de unidades de atendimento de emergência. A metodologia de pesquisa envolveu uma revisão da literatura, coleta de dados e análise de tarefas críticas nos processos de arrumação de leitos hospitalares para ocupação e desocupação de leitos. O estudo identificou atividades demoradas e propôs intervenções com base nos princípios da TRF para reduzir o desperdício e melhorar a eficiência. Os resultados destacaram a importância da comunicação eficiente entre enfermeiros e a equipe de limpeza, a execução paralela de tarefas por várias pessoas e a instalação de estruturas auxiliares para facilitar o movimento e reduzir o tempo de deslocamento. O modelo de pesquisa forneceu um roteiro para implementar a TRF e demonstrou seu potencial para otimizar os processos de saúde em unidades de atendimento de emergência. Sugere-se pesquisas adicionais para avaliar outros processos internos e analisar o cenário geral para alcançar melhorias abrangentes nas unidades de atendimento de emergência no Brasil. A integração de ferramentas da TRF e *lean healthcare* mostra-se um avanço necessário no setor de saúde, alinhando as expectativas dos clientes com inovações tecnológicas e atendendo às novas demandas no campo da saúde.
Palavras-chave: *Lean healthcare*; Troca Rápida de Ferramentas; Toyota *Kata*; Jornada do paciente; UPAs.

Lean Healthcare: evaluación de *Single Minute Exchange of Die* y Toyota *Kata* aplicados en las Unidades de Emergencia brasileñas

Resumen
Este estudio tuvo como objetivo evaluar la implementación de la metodología de Cambio Rápido de Herramientas (SMED, por sus siglas en inglés) basada en el concepto Toyota Kata en el contexto de las unidades de atención de emergencia. La metodología de investigación involucró una revisión de la literatura, la recopilación de datos y el análisis de tareas críticas en los procesos de preparación de camas hospitalarias para la ocupación y desocupación de las mismas. El estudio identificó actividades que consumen mucho tiempo y propuso intervenciones basadas en los principios de SMED para reducir el desperdicio y mejorar la eficiencia. Los resultados destacaron la importancia de una comunicación eficiente entre los enfermeros y el equipo de limpieza, la realización simultánea de tareas por varias personas y la instalación de estructuras auxiliares para facilitar el movimiento y reducir el tiempo de desplazamiento. El marco de investigación proporcionó una guía para implementar SMED y demostró su potencial para optimizar los procesos de salud en las unidades de atención de emergencia. Se sugieren investigaciones adicionales para evaluar otros procesos internos y analizar el panorama general con el fin de lograr mejoras integrales en las unidades de atención de emergencia en Brasil. La integración de herramientas de SMED y lean healthcare representa un avance necesario en el sector de la salud, alineando las expectativas de los clientes con las innovaciones tecnológicas y atendiendo las nuevas demandas en el campo de la salud.
Palabras clave: *Lean healthcare*; SMED; Toyota *Kata*; Jornada del paciente; Unidades de emergencia.

Introduction

Maximizing the perceived value of services provided to customers is the main goal of the healthcare field (SINGH; VERMA; KOUL, 2022). In this context, the referred services are healthcare and treatments for the patients (ARIEL FRANCO *et al*., 2020). Healthcare organizations operate in a challenging political and social climate, where their activities and behaviors are publicly known and investigated, and their performance and progress can be as important as the final outcome (ARIEL FRANCO *et al*., 2020; WALSHE; SMITH, 2011). Managers and leaders must balance competing, fluctuating, sometimes irreconcilable demands from a wide range of stakeholders, and the social, economic, and political context in which they operate makes leadership much more difficult. Also, especially in developed countries, the healthcare sector is subject to four challenging social trends (ARIEL FRANCO *et al*., 2020; WALSHE; SMITH, 2011).

The first challenge is the demographic shift. The fact that people are living longer produces a rise in the number of elderly people, and those people rely heavily on the healthcare system, much more than their younger counterparts. They are more likely to develop diseases and cost more to treat.

The second challenge is technological innovation, because new discoveries considering treatment possibilities are often more expensive than existing ones, but it also means that it is possible to save lives that would otherwise be lost if those options were not available.

Next are customer expectations. Their requirements are becoming increasingly demanding, and clients expect to be informed and involved in any decisions that affect their health. Customers are better informed and often know about and demand new and expensive treatments.

Finally, the first three trends are responsible for the upbringing of a fourth one, which is rising costs. Each of them contributes to the constant pressure for more healthcare funding, and it never seems to be enough.

Many healthcare systems are inefficient, and they end up inflicting more pain on customers (who shall be referred to as patients for the purposes of this study) than they provide benefits (LEITE; BATEMAN; RADNOR, 2020). Despite the fact that many of these inefficiencies are ingrained in business culture, they are the leading causes of patient unhappiness. Even though patient waiting times are considered to be one of the leading causes of their discontent (SRIRAM; NOOCHPOUNG, 2018), the literature

demonstrates that waiting experiences are often unfavorable and have been found to have an impact on customers' overall satisfaction with their service contact (BARLOW, 2002; BIELEN; DEMOULIN, 2007). Globally, there are not many studies focused on the evaluation of strategies for reducing waiting times in healthcare facilities (SILVA; SANTOS; ALVES, 2020).

Brazilian Emergency Care Units (ECU), located in the state of Rio de Janeiro, are the focus of this case study scenario. An ECU is a healthcare facility, which is part of the Brazilian federal government's free healthcare system — referred to as "SUS". This system intends to provide first-aid treatments as well as public health measures such as immunizations (vaccines) and disease prevention programs (SANCHES; BEDNASKI, 2021).

Few studies have reported on the use of Lean methodologies with a focus on reducing outpatient lead time, patient length of stay, or waiting time between activities, among others (PEIMBERT-GARCÍA; GUTIÉRREZ-MENDOZA; GARCÍA-REYES, 2021). Specifically in the Brazilian public sector, there are problems associated with the chronic lack of planning and management since the growth of the sector seems to take into account transversal themes with low adherence to the needs of the population (SANTOS; CALADO; ORLANDO FILHO; BOURGUIGNON, 2021).

However, in contexts where work is standardized, a key principle in both SMED and Toyota *Kata*, the incidence of HAI is significantly reduced. This finding reinforces the need for structured planning and risk identification in different hospital sectors (DE AMARAL; CALADO; VIEIRA; CHAVES, 2021).

The major goal of this study is to evaluate the workflow in the ECUs under consideration, assess it, and identify the activities that cause a bottleneck in the process and delay service delivery to the patient. The effectiveness of the SMED technique will next be assessed and presented in this specific situation. The problem question guiding this study is: how can the SMED methodology be effectively applied to improve patient flow in Emergency Care Units? The authors hope to contribute to a more efficient healthcare system and make the entire procedure more enjoyable for patients to go through, be it reducing waiting times or enhancing process efficiency and reducing response times.

Background

Brazilian Healthcare System

Even though the SUS model presented in the Brazilian constitution is seen as an example to other healthcare systems in many countries, most of the times the foreseen method is not applied in reality, turning it into a precarious system (CAMPOS, 2018). Accessibility is a key concern in Brazilian public health (TESSER; NORMAN; GÉRVAS, 2019). Prioritization of preferential groups, such as the elderly and pregnant women; and an overemphasis on prevention, which overburdens the system with excessive — and sometimes harmful — activities, such as routine appointments, periodic breast cancer screenings for people under 50, yearly uterine cancer screenings, and so on (TESSER; NORMAN; GÉRVAS, 2019).

Another issue is the system's excessive bureaucratization, which translates to limited appointment hours (threatening working-class access), receptionists with inadequate communication skills, slow administrative processes in comparison to available technology, and an excessive number of people in the system (TESSER; NORMAN; GÉRVAS, 2019). Even though the problem might be readily fixed over the phone or through instant messaging, the institutional culture frequently demands in-person contact at every demand. This leads to an increase in workload, longer wait times, weariness, tension, and conflict within staff teams (TESSER; NORMAN; GÉRVAS, 2019), all which directly impact on the set-up time of the processes.

In addition, lack of space, equipment, and basic resources; infrastructure; unsanitary environments; insufficient healthcare providers (doctors, nurses and physicians) and their concentration only in large cities; bad teamwork; precarious technology; and lack of funding are all issues with this system. The latter being the most critical, given that ECU expenses continue to rise while the government provides less and less funding (TESSER; NORMAN; GÉRVAS, 2019).

The SUS services are divided into three categories based on the amount of attention required: primary, secondary and tertiary, with the purpose of better managing the system's operations and services (BRASIL, 2011; BRASIL, 1990).

The Basic Health Units (BHU) and Family Health Units (FHU) constitute the primary category. This section focuses on low-risk treatments, as well as the promotion, prevention, diagnosis and precocious treatment of patients, which requires ongoing patient monitoring to minimize avoidable problems (BRASIL, 2017; KULICZ; USCOCOVICH, 2021). According to Souza *et al*. (2019), 80% of cases fall into this category.

The secondary category is composed by Emergency Care Units (ECU), which are the main focus of this paper. They are simplified hospitals and can be accessed at all times of the day, all days of the week, at no cost to the patient (KULICZ; USCOCOVICH, 2021). Patients are admitted according to their risk level, and those with the highest risk are treated first, rather than those who arrive first (BRASIL, 2011; BRASIL, 2017). Currently, the Manchester Triage System (MTS) is the most used classification protocol on those units. ECUs have the resources to treat the majority of emergency cases related to health, such as emergency appointments, exams, laboratories, hospital beds and similar services.

Despite the fact that ECUs rely on this classification methodology, individual attention is required to verify the accuracy of the provided information as well as the patient's pain level (RIQUETTA, 2018). ECUs have become the target of many patient demands, creating an overcrowded environment, increasing waiting times, and jeopardizing urgent cases due to the difficulty in scheduling appointments, the scarce availability of health professionals and medicine, distant exam scheduling and the longtime span between appointments (RIQUETTA, 2018). Furthermore, in ECUs, conflicts resulting from a lack of understanding of risk classification and excessive wait periods for medical care or operations have become typical.

The tertiary category is reserved for hospitals, which promote a series of therapies and specialized procedures, involving high technology (BRASIL, 2011). If a patient's case is deemed too complicated for an ECU, the patient may be sent to a hospital for treatment, which is also provided free of charge (both the hospital stays and the ambulance ride). This is frequently the case for emergency surgery and serious accidents (KULICZ; USCOCOVICH, 2021).

Although there are other tactics and philosophies for minimizing waiting times, the SMED technique was chosen for this purpose due to its focus on reducing the total amount of time spent in process activities (ROSA; SILVA; FERREIRA; CAMPILHO, 2017). Furthermore, there were not many concrete sources linked to the effective implementation of SMED in emergency rooms and hospitals, which creates a favorable atmosphere for research and innovation.

Lean Management

Lean manufacturing was created by Taiichi Ono and Shigeo Shingo and first emerged in the Toyota production system. It is described as an integrated socio-

technical system whose major goal is to minimize waste by simultaneously lowering or minimizing supplier, customer and internal variability (ARNHEITER; MALEYEFF, 2005; ROTTER *et al*., 2019). It is commonly regarded as a waste identification and removal asset, although the focus has shifted to culture development in recent years (CHARRON; HARRINGTON; VOEHL; WIGGIN, 2014).

When Lean was first introduced, the typical and traditional production strategy was based on high volumes, long wait times during operations and large batch sizes, which typically resulted in inferior quality because defects frequently go unnoticed until later down the production line by further operations or the final quality check, after the product had already been completed. In the worst-case scenario, the flaws would only be discovered in the client's hands (ARNHEITER; MALEYEFF, 2005; SINGH; VERMA; KOUL, 2022). On the other hand, Lean focuses on smaller batches, with the goal of having a batch consisting of only a single item, allowing for as much make-to-order as possible (SINGH; RATHI, 2019).

Lean can be introduced as a focused and methodical way to approach and steer employee learning, education and practice across a company. Individual and collective organization transformation plans aimed at developing a lean change management system can be included (CHARRON; HARRINGTON; VOEHL; WIGGIN, 2014). There is no uniform technical definition of Lean management (PETTERSEN, 2009; ROTTER *et al*., 2019), which has sparked a dispute in the operations management (OM) industry regarding what the concept really means (ROTTER *et al*., 2019).

Lean includes several pillars that are associated with the reduced batches and inventory, the first one being variability reduction. Variability is a broad term with many different meanings. It might refer to quality criteria like length, width and thickness, as well as delivery time, data processing and analysis, and shifts in working hours (especially downtime, absenteeism and lack of employee qualifications). Product and labor time variance, as well as the supply chain, can be improved through a clear partnership based on collaboration and communication between suppliers and manufacturers, as well as a standard with the work process evident (ARNHEITER; MALEYEFF, 2005; SINGH; RATHI, 2019).

The second pillar is waste elimination. Rather than focusing on enhancing performance, Lean Management aims to improve customer value. Only procedures that add value to the final products in the hands of the client are profitable (HALLAM; CONTRERAS, 2018). It is critical to understand the value chain when following these

instructions, and if an activity is not identified as providing value, it must be disconnected and eliminated (TLAPA *et al*., 2020).

The next pillar is perfection, which is at the core of what Lean Management aims to be and represents, and which can only be achieved via continuous and laborious improvement (Kaizen). To make this a reality, everyone in the organization must be, desire to be, and have the resources to be exceptional; the process has to be standardized, stable and transparent; and this must be a company-wide goal (BAUER; BRANDL; LOCK; REINHART, 2018).

Finally, Lean also aims for zero quality control (ZQC). Quality requirements must be met in order to achieve the above-mentioned pillar of perfection. However, using quality control is typically a costly, inefficient and time-consuming operation, which can lead to a lack of contribution in the process's value chain in the long term. Quality is "conformance to requirements" (SALVI; KERKAR, 2020). Every process, as well as every manufactured product, would meet the quality requirements in an ideal Lean firm, eliminating the need for quality control for a given activity. This can be accomplished using a variety of settings and methods, including a fully error-proof machine or system (*Poka-Yoke*), automated audits or inspections, statistical process control, and more.

Lean Healthcare

As previously stated, Lean is a methodology that was first applied in manufacturing, but this is not a prerequisite for its application in other fields. Every area that is made up of processes, or a conjunct of actions, that deals with value creation and has people relying on it has a quota for the application of Lean, and maximizing the perceived value of services provided to customers is the main goal of the healthcare field (SINGH; VERMA; KOUL, 2022). Lean Healthcare, or the application of Lean principles and methods in healthcare, aims to enhance the overall efficiency of clinical treatment in hospitals, save costs and improve patient outcomes (TLAPA *et al*., 2020).

Client specification, leadership, interdisciplinary teams, focus on patient flow, implementation and others, are among the pillars of Lean Healthcare that must be addressed in order to increase project success rates (TLAPA *et al*., 2020). The focus on the patient flow demands the creation of a value stream capable of addressing the needs of both operators and patients. These solutions should be created utilizing readily available data that is clear and visible.

Client specification creates a must in the value stream, be pointed to the main customer, the patient, another pillar should be the hospital's leadership who needs to be involved and perceived as by the employees to make sure the project is seen as a priority. Those managers should have management abilities. Second, that follows the multidisciplinary team, nothing less than a group who participates directly in the work responsible for problem-solving.

External consultants can be quite helpful in improving the thinking of the staff. Using modest tasks at first can encourage staff participation, and while goals should be high, they must be completed in order to inspire workers. Goldratt and Cox (2018) establish a long-term cycle that needs ongoing improvement and leads to higher quality and inventiveness. Process standardization, which includes documenting each new technique, results in the reduction of process variation and predictable results. Each stream should have a process leader who is in charge of the metrics for that stream.

SMED (Single-Minute Exchange of Die)

Engineer Shigeo Shingo invented the SMED technique in his 1985 book "Revolution in Manufacturing: The SMED System," and it is known as a scientific way to reduce process set-up time that can be used in any situation (BIN CHE ANI; BIN SHAFEI, 2013). Improvements in process efficiency can be achieved by reducing set-up times without compromising product quality (FONDA; MENEGHETTI, 2022).

It is described as the "minimum amount of time required to change the kind of production activity when the last piece of a previous lot is considered the first piece generated by the succeeding lot" (SHINGO, 1985). According to the technique, set-ups should be completed in less than 10 minutes, which can be achieved through work simplification by the machine operator (PATTARO JUNIOR *et al*., 2022).

According to Shingo, there are a few stages that must be followed for the SMED approach to be successfully implemented in a process, which is documented as follows.

- **Separating internal and external set-up:** for this purpose, internal set-up is the type of set-up activity that may happen only when the process has stopped; whereas external set-up activities are possible to attain with the process still running (BIN CHE ANI; BIN SHAFEI, 2013). Considering as much of the set-up operations as external might save as much as 50% of the time required for internal set-up (SHINGO,

1985). This may be accomplished by creating a check-list or check-table of all the processes necessary in an operation, which could then be separated further. Using broad checklists for a whole procedure should be avoided. They should instead be as descriptive as feasible.

- **Converting internal to external set-up:** operations should be analyzed to confirm that there are no steps wrongly assumed to be internal. If that is the case, the operating conditions should be prepared for conversion, trial shots should be conducted and then, finally, the operation should be converted to external.
- **Streamlining all aspects of the set-up operation:** each procedure shall be subjected to a thorough examination in order to improve it. Improvements in the storage and transportation of components and tools normally help external activities run more smoothly, but they are not sufficient on their own. Internal operations can benefit from a variety of methods, including simultaneous operations, the use of functional clamps to keep things in place with little effort, the elimination of adjustment demands and the relations combinations indicated.

Methodology

The objective of this study was to evaluate a method to implement SMED based on the Toyota *Kata* concept. This context defines evaluation as judging the worth or merit of an evaluation object based on predetermined criteria (WORTHEN; SANDERS; FITZPATRICK, 2010).

For this, the SMED methodology was used, focusing on reducing waste from critical set-up activities; and the Toyota *Kata* philosophy, in the form of scripted cycles of learning and continuous improvement. Worthen, Sanders and Fitzpatrick (2010) also describe the inquiry and judgment evaluation methods that were used for conducting research activities. To begin with, the criteria and standards for judging quality were determined, as well as whether they should be relative or absolute. Following that, the relevant information is collected according to the following paragraphs. The obtained results are then compared with the defined standards for determining value, quality, utility, effectiveness and significance.

The research was conducted through five phases. The first phase was a literature review based on Ferenhof, Cunha, Bonamigo and Forcellini (2018). The following search string was used: ("health organization" OR "healthcare" OR "health care" OR "hospital operations" OR "health services") AND ("SMED" OR "single-minute

exchange of die" OR "quick change"). Sources used for this are linked to publications in the business, management, service engineering and health areas. Among them, it is possible to name: Scopus, Web of Science, Emerald Insight, PubMed, Ebsco and Science Direct. Non-academic sources and works not in English, Portuguese or Spanish were not contemplated in this research.

The second phase was a content analysis based on Bardin (2011). Initially, the titles and abstracts were evaluated to create a portfolio containing articles and a thesis related to SMED and *Kata* implementation, both in the health area and in other areas. Then, the obtained portfolio was filtered to pick which works would in fact be used to create the method, with the use of a bibliography management software (EndNote). Duplicates were eliminated and, after a thorough reading of the contents of the remaining articles, the ones used in this study were chosen with the guidance of the following prerequisites:

- Does the material comprehend and explains correctly the principles of SMED and *Kata*?
- Does the material define clearly the problem and its goals?
- Are *Kata* and SMED used correctly?
- Were the results obtained satisfactory?
- Does the material explicit its limitations, obstacles and inhibitors?

The third phase was the construction of the proposed method *per se*. The remaining works had their used methods and obtained results compared, and the ones which better demonstrated what was effectively done and got the most effective results were selected.

The fourth phase was collecting data empirically. For that, an ECU located in the North Zone of the state of Rio de Janeiro was chosen, given its proximity and convenience. The set-up activity to be improved was chosen according to which of them was considered critical, that is, the one that had the highest rate of waste in relation to their total time, and the importance they play in the process in general. For this, initially, a diagnosis was carried out through analysis of the recognition of the value stream within the ECU studied. At this stage, an interview with a coordinator of the ECU under study was conducted.

Initially, it is necessary to distinguish the work elements used to develop this work. They are processes, activities and tasks (RIBEIRO *et al*., 2010), where:

- **Process:** logically linked activities and tasks that use resources to generate results. They aim to fulfill a specific organizational objective. Eg: triage.

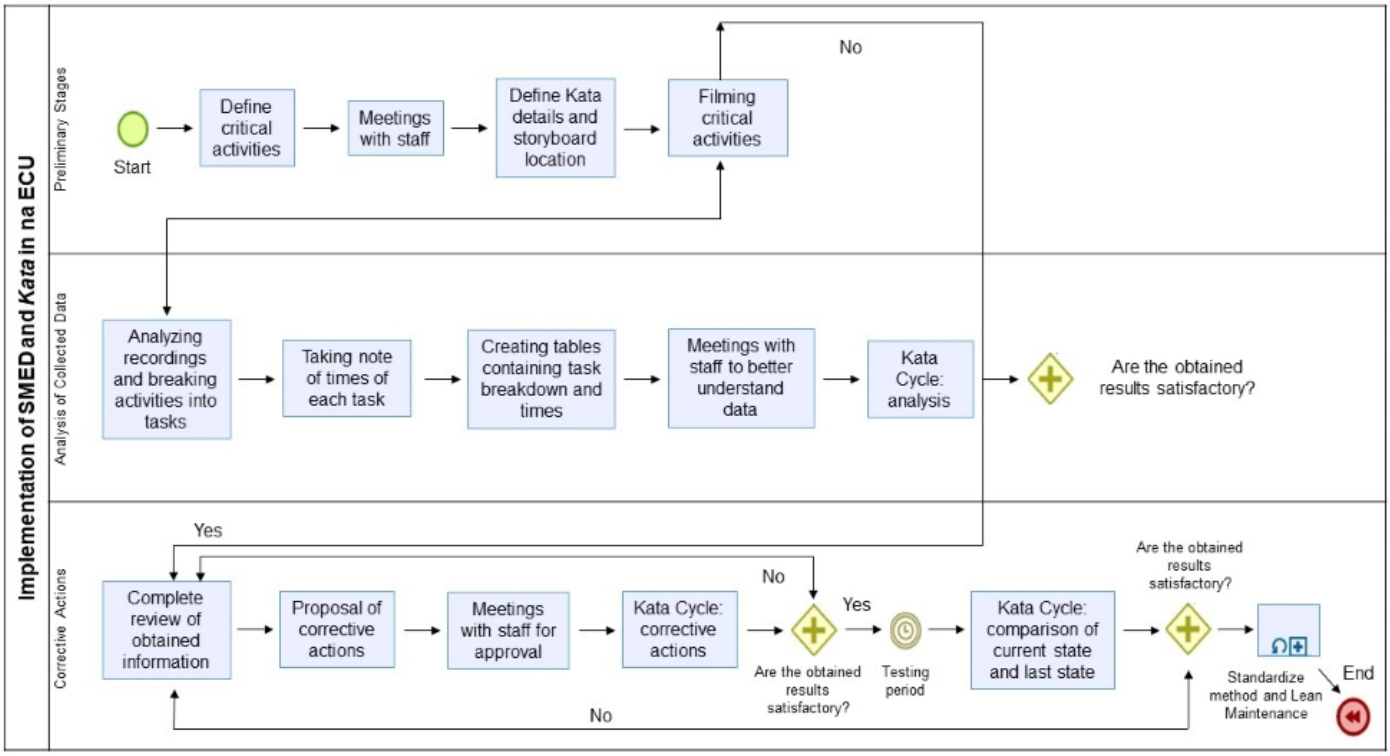
- **Activity:** result in a partial product that will make up the final product of the process. It is a set of tasks. Eg: patient check-in.
- **Task:** smallest unit of work to be carried out, involving routine and determined deadline. Known as a specific part of the activity. Eg: collect patient documents.

After choosing the activity, one must identify all the tasks currently performed to carry out this activity. This was done through filming, which also allowed to obtain the time that each task takes to be carried out; consequently, the total time of the activity. The information obtained was then arranged in a table, containing the name of the activity, a list of tasks and the time in seconds of each task, as well as the total time of the activity.

The last phase was the evaluation and prescription of *Kata* and SMED. After analyzing the tables constructed, it was conducted a meeting with staff to better understand the context of the obtained data, and which were the inhibitors of improvement that were in course. Then, considering their inputs, the critical tasks were identified, and possible solutions were named, according to the principles of Lean.

To better illustrate the described method, a flowchart based on BPMN notation was elaborated, and it is presented in Figure 1.

Figure 1 – Proposed methodology flowchart



Source: The authors (2023).

Next, the data collected following the methodology described above, the prescribed improvement *Kata* and the suggested implementation of SMED will be presented.

Results and discussions

Based on the described method, the first phase of the evaluation was a literature review. The authors searched for works that met the criteria presented above with the aid of a bibliography management software, obtaining 560 works.

Then, during the content analysis phase, 19 duplicates were found, resulting in 541 works. These were manually reviewed to check if their content would add value to this study. After the review, eight articles were selected to compose the evaluation method.

With that in mind, based on the works of Worthen, Sanders and Fitzpatrick (2010), Guzel and Asiabi (2020), Improta *et al*. (2018) and Sarmento, Sanches and Santos (2018); and Toyota *Kata* application was based on Cohen (2018), Souza and Pidd (2011), Ferenhof, Cunha, Bonamigo and Forcellini (2018) and Rother (2009), it was possible to assemble the SMED application suggested for this evaluation study. The research framework was based on March and Smith (1995). The topics below describe the results obtained according to the flow proposed in Figure 1.

Preliminary stages

Based on flow analysis and timely data, two critical activities were selected: arranging hospital beds for occupancy and vacating these beds. Subsequently, both selected activities were broken down into tasks, according to the description of the work elements. Then, temporal data collection of these tasks was performed by filming and timing them from start to finish, in seconds. The temporal data are shown in Tables 1 and 2, presented below.

Table 1 - Data of arranging hospital beds for occupancy activity

Activity: arranging hospital beds for occupancy	
Task Name	**Time (s)**
Wait to start the process after previous patient liberation	300,00
Move the table away from the bed	1,40
Turn crank to adjust bed level	13,04
Move bed away from the wall	4,40
Lower guardrail	1,13
Walk to the nurses' station	4,10

Continua

Conclusão

Activity: arranging hospital beds for occupancy	
Task Name	**Time (s)**
Pick up sheets at the nurses' station	5,00
Walk to bed	4,10
Position fitted sheet on the bed	23,83
Fold bed sheet	3,06
Place bed sheet on the covered bed	1,32
Raise guardrail	0,86
Put bed back in place	5,87
Walk to the nurses' station	4,10
Pick up devices at the nursing station	5,00
Walk to the table	4,10
Position disposable intubation material on the table	2,00
Position sterile permanent material on the table	2,00
Open black briefcase on the table	1,00
Check laryngoscope blades and handle	3,00
Close black suitcase	1,00
Walk to the nurses' station	4,10
Pick up oxygen reservoir mask	3,00
Walk to bed	4,10
Position oxygen reservoir mask above bed	11,13
TOTAL	**412,64**

Source: The authors (2023).

Table 2 - Data of vacating hospital beds activity

Activity: vacating hospital beds	
Task Name	**Time (s)**
Collect bed sheets	10,70
Take dirty sheets to the nurses' station	4,10
Walk to the table	4,10
Collect disposable material from the table	10,83
Walk to the nurses' station	4,10
Throwing disposable material in the trash	3,66
Walk to the table	4,10
Collect permanent material	11,87
Bring permanent material to the nurses' post for sterilization	4,10
Walk to the table	4,10
Open black briefcase on the table	0,88
Collect equipment from the laryngoscope and store it in the suitcase	19,35
Close suitcase	0,68
Reposition the table	1,66
Notify availability to the cleaning team	200,00
Wait for the cleaning team to arrive in the room	600,00
Hospital bed hygiene	600,00
Wait for bed to dry naturally	390,00
TOTAL	**1874,23**

Source: The authors (2023).

Then, the location of the Storyboard should be decided. This location should preferably be easily accessible to all those involved in the analyzed activities. At the

same time, it is important to avoid having the Storyboard located in areas with a heavy flow of people, as sessions can either be disrupted by noise or interruptions, or interfere with other operations.

It also needs to be defined the frequency of *Kata* sessions, and who will play the roles of coach and apprentice. In terms of frequency, weekly sessions are suggested at low-traffic times (few patients intake). As for the roles, it is recommended that the coach be an experienced employee, who knows the process well and has been involved with it longer than the others. It is important to train him so that he knows the principles of Lean, SMED and *Kata* well, and has the decision-making capacity to apply these principles in practice in the best possible way. The apprentice must also be a person involved in the process, chosen by a vote of the others, or by volunteering.

Sessions must follow the script established on the Storyboard and on the attached card, leaving space for questions and comments at the end; and be finalized with a goal to be achieved by the next session, decided between the coach and the learner.

Analysis of collected data

After *in loco* data collection, they were structured in electronic spreadsheets and presented to ECU professionals for review and consensus. Some reports were identified as "there is no efficient communication system between nurses and the cleaning team, and everything is done via verbal informal communication. Both activities are also not seen as a priority by the members of this team, which causes them to take longer than necessary to get to the room".

It is also known that, although the task of waiting for the bed to dry naturally is time consuming, it is not possible to dry the bed in any other way, due to hospital hygiene standards. In addition, it is not possible to move the bed or move it away from the wall, due to equipment connected to the bed; for example, oxygen tubing. The same goes for the nursing station, which is fixed to the wall.

With the results obtained and presented in the tables above, the critical tasks for both operations were identified. For the arrangement of beds, the activities of moving and positioning the bed are considered critical, as they do not add value and can be eliminated. In the activity of vacating beds, the critical tasks are those that involve waiting for the cleaning team, as they make up most of the activity time and do not add any value.

Corrective actions

After deciding on the details of the *Kata* cycle, the first session is held, where the interventions described below will be proposed, based on the principles of SMED. These proposals will serve as the initial action, and subsequent cycles should build on them, until the goals are met. After that, it is up to the coach and the apprentice to discuss in search of future improvements to be made in the activities, or to carry out the maintenance of the reached state.

That being said, there needs to be an efficient communication system between nurses and the cleaning team, as this is the delay that most impacts the total time of the activity. A visual system is suggested, through lights installed in the cleaning room, and remotely controlled by the bedrooms. When a room needs cleaning service, the nurse in charge must press the button, which will flash red on a panel in the cleaning room, indicating the room that requires attention. After meeting the demand, the nurse will activate the button again, and the light will return to the default color (green).

It is recommended that, despite the possibility of using different colors, that a system where the lights normally remain off, turning on in case of attention, is not used, as this type of system makes it difficult to perceive a possible defect in the lights. It is also suggested that the color change of the lights be accompanied by some type of symbol or sound warning, in case any of the employees has reduced color perception (color blindness).

The cleaning team's response time to the call is also influenced by the perception of value of these employees, who do not judge the activity as being of great importance in relation to others. It is necessary to educate them, and make them understand that, despite being a seemingly simple task, it affects other important tasks in several aspects, causing a "snowball effect", and increasing the patient's waiting time for the availability of a bed.

Regarding the tasks of the activity itself, there are two interventions that can be made. The first is to carry out the tasks of each activity in parallel, by two people instead of just one. This would save time as well as make certain tasks less laborious, for example covering the bed with a fitted sheet. This suggestion is not about carrying out the two activities simultaneously, but the internal tasks of each one of them.

The second intervention is related to movement activities. A lot of time is wasted in moving the bed to the nursing station and, despite the fact that moving the bed or

station is impracticable, it is possible to install auxiliary structures to mitigate the problem.

It is suggested to install a mobile wheeled cart with drawers, which has space to store some of the spare equipment contained in the nursing station, in order to reduce the amount of "travel" needed to reach equipment.

If possible, it is also recommended that the room where the cleaning equipment and the light panel are located be moved to a point relatively equidistant from all rooms with beds, in order to reduce the travel time of employees.

Armed with the data collected in the field, it was possible to prescribe the application of the method through the Storyboard presented in Figure 2, which simulates the first round of the prescriptive *Kata*.

Figure 2 - Example of Storyboard for use in ECUS

Challenge: Reduction of total patient journey time		
Activity: Arrangement/Vacating of Beds	**Apprentice:** XXX	**Coach:** YYY

Target-Condition	**Current Condition**	**Obstacles**
Reduce patient waiting time by 50% and total time of covered activities by 30%	Activities contain unnecessary and poorly optimized tasks	Cleaning staff do not have bed hygiene as a priority
Deadline: September 2022		

Register of Kata Cycles			
What do you plan?	**What do you expect?**	**What happened?**	**What did you learn?**
To train employees to understand the need for change, and to prioritize bed cleaning activities	To raise awareness to the need for change and identifying inhibitors preventing this change	The Apprentice pointed out the difficulty in perceiving the moment when a bed is released for cleaning	The communication system between nurses and cleaning staff is inefficient and needs to be improved

Source: The authors (2023).

Conclusion

The present study aimed to evaluate a method to implement SMED based on the Toyota *Kata* concept. Based on the findings, it was possible to assess the applicability of the proposal empirically. The outline of the conducted evaluation allows assisting health professionals in decision making in UPAs for the optimization of health processes.

When it comes to activity and behavior in the health area to be maximized and structured, aligning customer expectations with technological innovations and new demands in the health area by society and patients turn out to be a great challenge.

The use of tools such as SMED together with lean healthcare is a necessary advance in the health sector.

Analyzing the times of the activities in detail allows us to first understand how the processes as a whole work, allowing us from this analysis to evaluate the waste found in the studied study. In this study, it was possible to determine that most of the activities that generated waste came from movement.

With this study, it was possible to locate and identify critical tasks in the operations explained, as well as to suggest interventions for these tasks with the principles of SMED and *Kata*. The methodology of application of these tools in the context of the health area was explained, thus allowing the employees could achieve improvements in the most critical tasks.

For future research, an evaluation of other internal processes along with the positioning of the storage and examination rooms in these areas is suggested, as a holistic analysis of the scenario is of great importance for SMED and *Kata* implementation, and for achieving improvement of Brazilian Emergency Care Units.

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