Application of the Lean Principles of the Toyota Production System for the Improvement of the Emergency Service Attention Times of a High Complexity Hospital*

Aplicación de los principios Lean del sistema de producción Toyota para la mejora de los tiempos de atención del servicio de urgencias de un hospital de alta complejidad

Aplicação dos rincípios Lean do sistema de produção Toyota para a melhoria dos tempos de atenção de serviço de emergência de um hospital de alta complexidade

Received: 19 de may de 2022. **Accepted:** 17 de november de 2022. **Published:** 31 de march de 2023.

DOI: https://doi.org/10.11144/Javeriana.rgps22.alpt

Atilio Moreno Carrillo[a]
Pontificia Universidad Javeriana, Colombia
Hospital Universitario San Ignacio, Colombia
ORCID: https://orcid.org/0000-0001-9148-6111

Oscar Mauricio Muñoz
Pontificia Universidad Javeriana, Colombia
Hospital Universitario San Ignacio, Colombia
ORCID: https://orcid.org/0000-0001-5401-0018

Roxana Maria Díaz Porta
Pontificia Universidad Javeriana, Colombia
ORCID: https://orcid.org/0000-0002-0650-3026.

Key Messages The Toyota methodology is useful for identifying the most congested blocks, service cycle times and waiting times in the emergency department. It allows to identify those activities that did not add value to the healthcare attention process and affect its development.

[a] Autor de correspondencia. Correo electrónico: atilio.moreno@javeriana.edu.co

Abstract

Context: Toyota Production System is a way to discover opportunities for improvement, adaptation and change, through lean tools, in companies that are in conditions of constant change.
Aim: The objective of this study was to apply the lean principles of the Toyota Production System to improve attention times in the emergency department of the Hospital Universitario San Ignacio in Bogota (Colombia).

Methods: A mixed design was used in this study: First, a situational diagnosis of the processes of the emergency service of the Hospital was established, later the institutional behavior patterns (attention cycle times and waiting times) were statistically determined and lastly, improvement strategies were proposed to be implemented in the short and long term.

Results: Detailed knowledge of the service's operation was achieved. This study enabled the recognition of 13 general processes in the care route that varied according to the triage type, and areas with a greater flow of patients: information, triage, admissions, consulting room, sampling, and billing. Extended wait times were found in consulting room (109 min), sampling (29 min), x-rays(77 min), medical reassessments (160 min) and billing (18 min). Likewise, 23 activities that did not add value to the process were identified. Multiple improvement strategies were proposed with a special focus on three specific areas: admissions, sampling, and billing.

Conclusions: The implementation of the lean principles in the health sector provide the guidelines for an adequate improvement plan of the emergency service, allowing for opportunities such as inclusions of just-in-time activities (continuous flow and kanban), standard work and levelling in the attention process.

Keywords: Lean Manufacturing, Toyota Production System, Lean Healthcare, Colombia, Emergency Service.

Resumen

Contexto: el Sistema de Producción Toyota es una forma de descubrir oportunidades de mejora, adaptación y cambio, a través de herramientas lean, en empresas que se encuentran en condiciones de cambio constante.
Objetivo: el objetivo de este estudio fue aplicar los principios lean del Sistema de Producción Toyota para mejorar los tiempos de atención en el servicio de urgencias del Hospital Universitario San Ignacio de Bogotá (Colombia).

Métodos: en este estudio se utilizó un diseño mixto: Primero se estableció un diagnóstico situacional de los procesos del servicio de urgencias del Hospital, posteriormente se determinaron estadísticamente los patrones de comportamiento institucional (tiempos de ciclo de atención y tiempos de espera) y por último se propusieron estrategias de mejora para ser implementadas en el corto y largo plazo.

Resultados: se logró un conocimiento detallado del funcionamiento del servicio. Este estudio permitió reconocer 13 procesos generales en la ruta de atención que variaron según el tipo de triaje, y áreas con mayor flujo de pacientes: información, triaje, admisiones, consulta, toma de muestras y facturación. Se observaron tiempos de espera prolongados en consulta (109 min), toma de muestras (29 min), radiografías (77 min), reevaluaciones médicas (160 min) y facturación (18 min). Asimismo, se identificaron 23 actividades que no añadían valor al proceso. Se propusieron múltiples estrategias de mejora, con especial atención a tres áreas específicas: admisiones, toma de muestras y facturación.

Conclusiones: la implantación de los principios lean en el sector sanitario proporcionan las pautas para un adecuado plan de mejora del servicio de urgencias, permitiendo oportunidades como inclusiones de actividades just-in-time (flujo continuo y kanban), trabajo estándar y nivelación en el proceso de atención.

Palabras clave: fabricación ajustada, sistema de producción Toyota, asistencia sanitaria ajustada, Colombia, servicio de urgencias.

Resumo

Contexto: O Sistema de Produção Toyota é uma forma de descobrir oportunidades de melhoria, adaptação e mudança, através de ferramentas lean, em empresas que estão em constante mudança.
Objetivo: O objetivo deste estudo era aplicar os princípios lean do Sistema de Produção Toyota para melhorar os tempos de atendimento no departamento de emergência do Hospital Universitário San Ignacio em Bogotá (Colômbia).

Métodos: foi utilizado um desenho misto neste estudo: primeiro, foi estabelecido um diagnóstico situacional dos processos do departamento de emergência do Hospital, depois foram determinados estatisticamente os padrões de comportamento institucional (tempos de ciclo de atendimento e tempos de espera) e, finalmente, foram propostas estratégias de melhoria a serem implementadas a curto e longo prazo.

Resultados: Foi alcançado um entendimento detalhado do funcionamento do serviço. Este estudo nos permitiu reconhecer 13 processos gerais no percurso de atendimento que variaram de acordo com o tipo de triagem, e áreas com maior fluxo de pacientes: informação, triagem, internações, consulta, amostragem e faturamento. Foram observados longos tempos de espera em consultas (109 min), amostragem (29 min), radiografias (77 min), reavaliações médicas (160 min) e faturamento (18 min). Além disso, foram identificadas 23 atividades que não agregaram valor ao processo. Foram propostas múltiplas estratégias de melhoria, com foco em três áreas específicas: admissões, amostragem e faturamento.

Conclusões: A implementação dos princípios lean no setor de saúde fornece as diretrizes para um plano de melhoria apropriado para o departamento de emergência, permitindo oportunidades como a inclusão de atividades just-in-time (fluxo contínuo e kanban), trabalho padrão e nivelamento no processo de atendimento.

Palavras-chave: produção enxuta, sistema de produção Toyota, saúde enxuta, Colômbia, departamento de emergência.

Introduction

The lean production system is a management strategy that is capable of adapting to all organizations and is based on the improvement of processes. Lean techniques are widely used throughout the manufacturing industry to provide just-in-time delivery of products and, ultimately, to create value for the consumer while using the least resources. “Lean” is a term related to philosophies derived from the Toyota Production System. The main goals of the lean system are to create standardized work to smooth out the workflow and to eliminate unnecessary steps in a process. The lean system concentrates on attaining continuous flow through a system by identifying value in each step of a process. If a step fails to add value or results in a redundancy to the next user in the process, it impedes quality and flow, and, therefore, is eliminated. With the reduction of waiting times between steps and the exact provision of what the next user in the process needs, quality and productivity are improved. Lean thinking emphasizes the identification of the root cause of a delay or problem by addressing the worker and workplace to understand the demands of the work. Front-line workers are taught to identify waste, and to improve and standardize their step in the process (1).

Today, the healthcare system uses the term “Lean Healthcare” with a direct focus on improving the quality and safety of patient care. This term has become a valuable tool for health institutions because it offers a system of continuous improvement that seeks to achieve effective and efficient management of daily activities (2). Lean healthcare is simply the application of the Toyota Production System to the health system, which consists of a set of techniques such as “just-in-time” and “jidoka”. On the one hand, just-in-time technique uses three tools: “continuous flow”, “PULL system” and “takt time” to be able to produce what is necessary, at the right time and in the right quantity. On the other hand, Jidoka uses the Japanese philosophy “Genchi Genbutsu” to avoid ovverlooking any failure of its production phase and thus to prevent defective products and manufacturing errors (3). All the named concepts are represented in the two great pillars of the Toyota house. Its base provides stability through standardized processes, a business culture aimed at long-term decision-making and a properly trained staff; the ceiling contains the desired results, the highest quality at a low cost and minimal waiting time (4).

The applicability of lean principles to the health sector is being increasingly studied. A recent systematic review evaluated the implementation of this approach in multiple emergency departments, most of them in Canada and the United States of America, showing in almost all the published studies that indicators have significantly improved (5).

In Colombia, there are very few studies on the adaptability of the lean production system to the health area (6-8), and none of these studies has sufficient evidence to directly evaluate the approach in emergency departments. Hence, the objective of this research was to apply lean principles to improve attention times in the emergency department of a high complexity universitary hospital.

Subjects and Methods

This research work used a mixed design (9). The study population included a non-probability sample of adult patients classified in triage (1, 2, 3, 4 and 5), and the administrative, operational, and healthcare staff who worked at the emergency department of the Hospital Universitario San Ignacio in Bogota (Colombia), between June 2018 and March 2019. To be included, the staff had to be working in the emergency service during the previous three months. Patients who attended obstetric or ophthalmology services were excluded, as they continue their treatment in another area of the hospital, outside the service. All the participants signed an informed consent. The institutional ethics committee approved the study.

Several visits were made to observe the care process, identify the main components, understand its operation, and validate what had been observed. Subsequently, semi-structured interviews were conducted with the head of nursing department, three collaborators from the health care staff, the head of billing office and the person in charge of admissions, to collect enough information. With this information, a block diagram of the process was developed, showing the general process of the service.

To achieve a detailed representation (current state), systematic observations of the areas defined in the block diagram were carried out. The “tracer patient” methodology was used, which consists of a quality tool that allowed the monitoring and evaluation of patient care in the emergency area. This tool enables the detection of waste in activities and long waiting times between processes. During patient care, difficulties and opportunities for improvement were identified.

Once the main processes of the service had been identified and understood, possible care routes were studied according to the patient's triage, and the areas with the greatest congestion in the flow of care, using the spaghetti diagram. Afterwards, service cycle times and waiting times were measured, and this information was captured in a single value stream map. A differentiation between the times collected in the morning and the times collected in the afternoon was established, and a calculation of the total times was made to obtain the average service time spent on care. To develop an exhaustive analysis and identify the waste in waiting time, the percentages of compliance with the previously established institutional goals were evaluated. Likewise, an analysis of efficiency and productivity was carried out. At the same time, activities that do not add value to the process were established and placed in the Toyota seven wastes classification.

The sessions of the Kaizen Group allowed a greater understanding of the service by the research team and validated the data collected; finally, a space for brainstorming was given, where some improvement strategies were proposed considering the findings.

Consecutively, the lean principles were analysed and confronted with the improvement opportunities to solve the flow problems in the emergency department. This relationship analysis

was intended to choose the appropriate principles for each opportunity and thus reduce waste in the process that was analysed. The principles that were considered were the 5S [a term based on 5 principles starting with the letter "S": In Japanese, Seiri (Sort), Seiton (Systematize), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain)] just-in-time and jidoka, which oversaw the creation of a solid foundation to guide the organization towards Lean thinking. However, exercises such as structured brainstorming, cause, and effect diagrams, as well as 5Ws could be useful to understand where the root cause of these wastes was, and to be able to work on them from there.

Results

Figure 1 shows the block diagram describing emergency room care process. 13 general steps were identified. It was evident that the process was different according to the triage classification of each patient: triage 1 and those arriving in ambulance immediately entered the resuscitation area or doctor's office; patients classified as triage 2 and 3 had a great variability in care process, since they could be discharged, left under observation or hospitalized; those classified as triage 4 and 5 were normally discharged with medication (sometimes intramuscular), and with an appointment for ambulatory care.

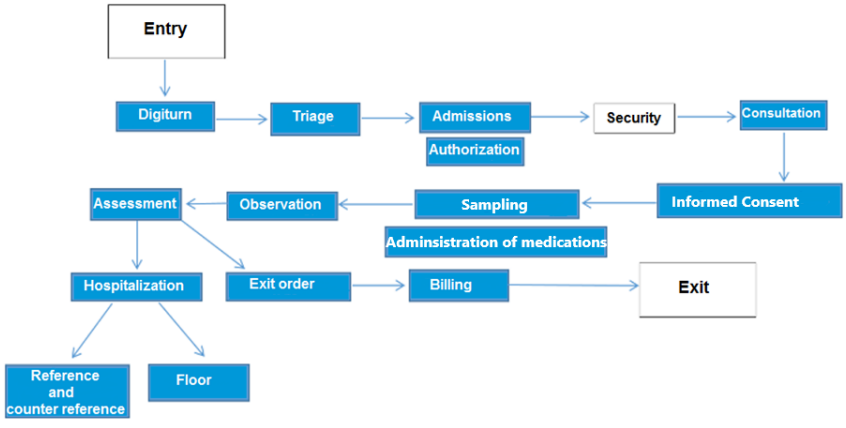

Figure 1. Block diagram describing emergency room care process.
Source: Own elaboration.

During the data collection period, an average of 399 patients per day arrived at the emergency department. Figure 2 presents the flow of tracer patients, showing that the areas with the greatest congestion were: information, triage, admissions, medical offices, sampling area and billing office. Some of these spaces are mandatory to enter to the service or for an effective hospital discharge. Up to 83 patients were observed simultaneously in the admission waiting room, exceeding the installed capacity. Similarly, a circulation of up to 51 patients was observed in

the medical consultation area, where 23 medical offices are available, indicating that some patients were accompanied. A maximum of 38 patients were observed in the waiting room of the sampling area, while the installed capacity in this area was only 25 chairs.

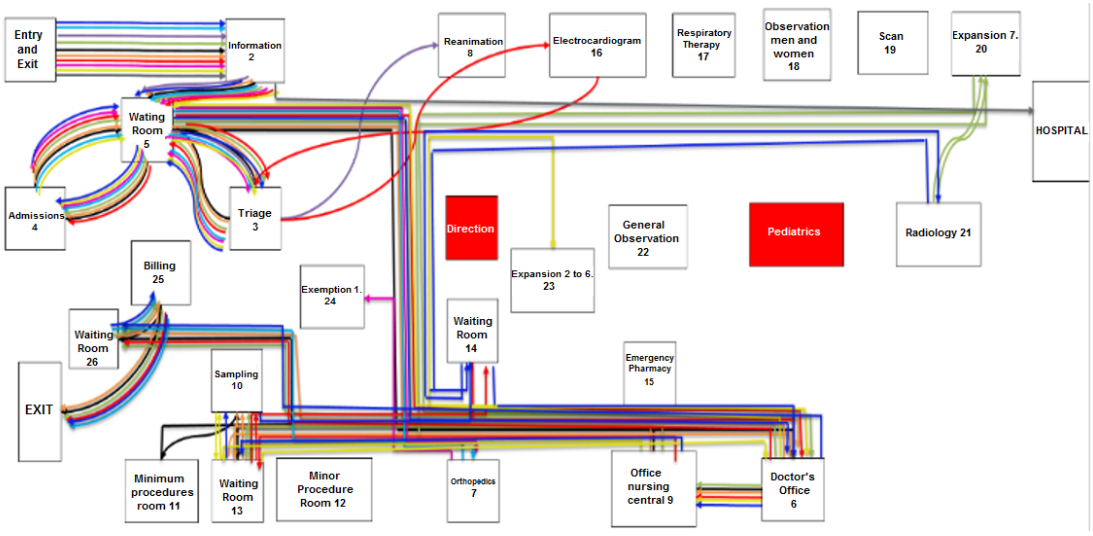

Figure 2. Flow of tracer patients in Emergency Department.
Source: Own elaboration.

Figure 3 shows the service cycle times and waiting times. Five processes drew attention due to the long waiting times: 109 minutes from the start of care until the medical consultation, 29 minutes before taking samples, 77 minutes waiting for the call for radiological examinations, 160 minutes for medical re-evaluations and 18 minutes for billing. The process with the highest work cycle time (CT) was the collection of samples for laboratory analysis (14 minutes), radiological examinations (42 minutes) and medical re-evaluations (24 minutes). It is important to note that radiological examinations, such as ultrasound, are performed in another area outside the emergency department. The total cycle time was 117 minutes on average.

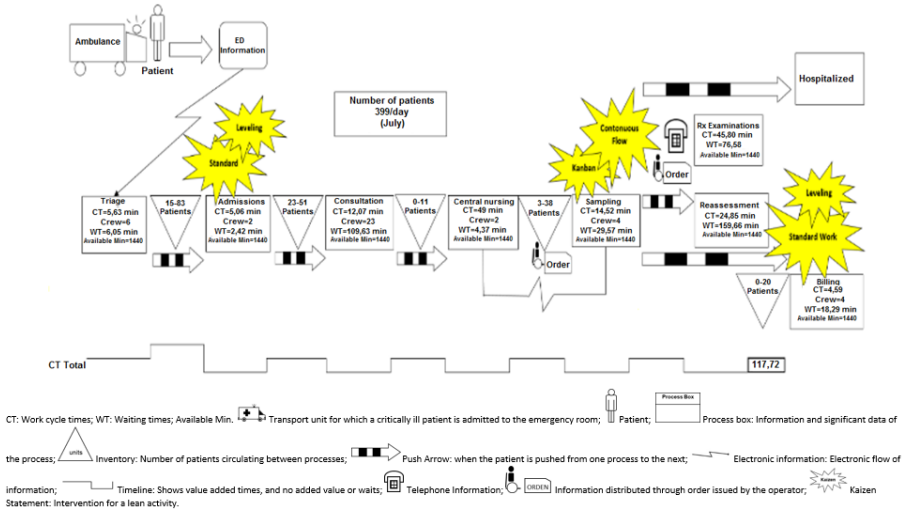

Figure 3. Service cycle times and waiting times in the emergency department and Kaizen Interventions for a lean activity.
Source: Own elaboration.

Table 1 shows the areas with the lowest percentage of compliance with institutional goals: admissions, sampling, radiological exams, and billing office. The latter with the lowest percentage (11%). The analysis of the value stream map of status revealed that the waiting times for the consultation are longer than the established goals because the times were not disaggregated by triage but were analyzed together. Thus, for the final analysis, different goals were considered for each triage classification: the average time until care for triage 1 was 0.3 minutes, with a maximum of 1.1 minutes; for triage 2 of 30.6 minutes with a maximum of 36.7 minutes, exceeding the institutional goal of 30 minutes; for triage 3, 59.7 minutes with a maximum of 72.9 minutes, time that is within the institutional goal of 60 to 90 minutes. The attention times for triage 4 were 110.1 minutes with a maximum of 136.7 minutes, a time that exceeds the established goal by 6.7 minutes; finally, for triage 5 it was 110.4 minutes with a maximum of 201.6 minutes, exceeding the goal established in 21.6 minutes.

Twenty-three activities that did not add value to the process and affect its development were identified. Of those, 39% were classified as defects, what means activities carried out incorrectly and implies that they need to be corrected or executed newly. Some examples are: 1) the lack of clarity in the signage, since it was evident that the patients were constantly asking where they should go; 2) the fact that the software used in the service crashes, increasing waiting times between processes; 3) the simultaneous functioning of speakers and digital shift system (digi-turn), interfering patients' proper listening of instructions on where they should go.

Seven activities were classified as process defects. It refers to work that has no value to the client, or when more work than required is done. Some examples are filling out the SIRAS (Sistema de información de reporte de atenciones en salud a victimas de accidentes de tránsito – Information system for healthcare reporting for victims of traffic accident) and SIRE (Sistema de información para el reporte de extranjeros – Information system for report of foreigners) forms by the officials at the admissions window, delaying the service process by up to 31 minutes.

Other activities that did not add value to the process were related with movement, inventory management and time (9% each one), and transport issues (4%), which refer to unnecessary movements and the risk of damage, loss or delay of a product or service. Some examples were the constant movement of nurses in charge of taking samples to the pharmacy and laboratory; the excess of patients moving from one room to another without supervision of the care staff; poor distribution of spaces; and lack of inventory in areas such as central nursing, sampling and billing.

With the aforementioned information, we proceeded to prepare a proposal for the desired state, aimed at improving the established times and waste, focused on three specific areas: admissions, sampling, and billing. The area of radiological examinations was not included, because it must be assessed differentially for X-rays and for ultrasounds, considering that they are performed at different sites and, in some cases, out of service, so a long-term intervention is recommendable.

Figure 4 present the value stream map of the future state, relating improvement opportunities with lean tools to be used. The action plan included just-in-time activities (continuous flow and kanban), standard work and leveling. The areas to be intervened are marked with a Kaizen outburst. The proposed improvement strategies to be implemented in the short term were:

1. An auxiliary nurse for the sampling area: this strategy seeks to generate an impact on the lack of inventory in the area, improve communication and provide suitable support to the patient, applying continuous flow and kanban interventions.
2. Reorganization of admissions area, using the information of the highest peaks in the flow of patients. For that, each collaborator should be studied, work schedules should be reorganized, and a laptop should be requested for execution: this tactic seeks to generate the best mechanism to reduce waiting times in the area, achieve compliance with the institutional goal and improve the order of attention in the service, through leveling and the standardization of processes.
3. Definition of a patient call mechanism for billing: through this strategy, the aim is to improve waiting times for the process, meet the institutional goal, impact on technological problems in the area (lack of inventories and changes in daily activities). Standard work and leveling should be used in the design.
4. Establishment of a visual signage system easily identifiable by the patient: the objective is to reduce the percentage of occurrence of defects, specifically referring to the diagnosis of poor communication with patients. To achieve this objective, it is necessary to implement tools such as visual lean management and the creation of a Kaizen group.

5. Enhancement of loudspeaker audio: this strategy seeks to impact the change with the highest percentage of defects in the study (39%) and specifically on the diagnosis of poor communication with patients. What is proposed for the improvement of the speaker's performance is a lean tool called Genchi Genbutsu (go and see).

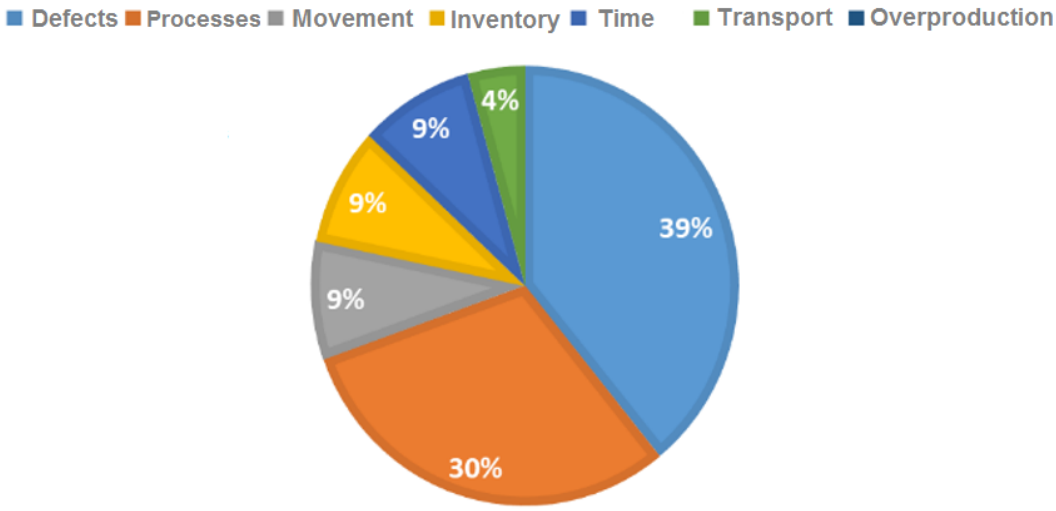

Figure 4. Activities that did not add value to the process and affect its development.
Source: Own elaboration.

Supplementary Table 1 presents the indicators, means of verification, and assumptions of suggested improvement strategies. As a long-term strategy, a review of the space available for the waiting room in the emergency area was recommended, since the installed capacity is surpassed by the demand. Additionally, it was proposed to review the protocols established for the minor and minimum procedure rooms, to reorganize the spaces.

Discussion

According to the San Ignacio Hospital's 2019 management report, in the month of December there were a total of 9,454 adult patients, out of which 6.34% of the patients were discharged without medical attention. The percentage of occupation over installed capacity was 199% and the rate of complaints in relation to the number of users served was 0.3% (Data not published). All these indicators were a motivation to study and diagnose the current state of emergency processes and provide strategies to improve attention.

Previous researches have revealed that methodology by phases of lean implementation resulted in the optimization of attention times (6). As an example, a study developed in Ontario Canada showed that the mean time between registration and physician attention decreased from 111 minutes to 78 minutes, and the length of stay (LOS) for discharged patients decreased from a mean of 3.6 to 2.8 hours after the implementation of the lean approach (10).

Some studies about the potential benefits of this approach in emergency areas in Colombia has been developed. A study carried out at the Universidad del Bosque, in Bogota (Colombia), evidenced a reduction in attention times in different emergency areas (admissions 32%; triage 29%; consultations 20%; medical procedures 53%; departures and billing 96%). The authors concluded that the proposed solution was in line with the main objective of the study, and recommended the use of lean in other units or healthcare centres in Colombia (11). A second study developed by researchers from the same university assessed the applicability of the lean proposal by means of computational simulations in a gyneco-obstetrics emergency unit located in Bogota (7), suggesting possible improvements in the attention times of up to 56%. In a similar way, a study performed in the Hospital Universitario de la Samaritana suggested in a preliminary report that the waiting time until attention decreased from 203 to 185 minutes after the implementation of the lean approach (8).

In this research, this methodology was applied with the following phases: 1. Value stream map of the current state, 2. Service diagnosis, 3. Value stream map of the future state, 4. Short and long-term improvement strategies, and 5. Continuous improvements. Van Goubergen and Lambert (12) found evidence that the tools used in the Toyota Production System can be extrapolated and applied in the health sector, and in this way we are able to obtain great results. The results obtained in the dermatology department of Ghent University Hospital were: Decrease in waiting times for appointments from cancer patients to less than one week and from regular patients to less than two weeks, a progress in the punctuality of patient care for the day of their appointment of 47% and an increase in patient satisfaction up to 80%. All the above demonstrates the effectiveness of the lean principles in the pillars of just-in-time and continuous improvement, as well as in the fundamentals of the Toyota Production System house. Like what was reported by our research, the principles that guided the improvement strategy proposal were just-in-time, standardized work and leveling, with which it is intended to guarantee the continuous flow of patients, standardize processes and level the tasks according to the demands.

The areas with the highest congestion by care routes in the spaghetti diagram were triage, admissions, consultation, sampling, and billing. According to the status value stream map, the areas with the longest waiting time (WT) were consultation, sampling, radiological exams (specifically ultrasound), reassessment and billing. It was found that admissions exceeded the time established as an institutional goal by approximately 4 minutes and that its percentage of compliance is 69%; which makes it possible to identify a problem that was not visible in the value stream map. Finally, it was decided not to include the consultation area for the approach of the short-term strategies, since the times were not taken by type of triage, however, at the time of review, verification and analysis of the information provided by the statistics department, it was observed that the data reflected compliance with the times established as institutional goals for triage.

Kalong and Yusof (13) reported in a literature review that the seven categories of waste in the manufacturing industry also exist in the healthcare industry, these being: Transportation, over-processing, over-production, inventory, waiting, movement, and errors. The results of our study

support this conclusion to the extent that twenty-three activities were identified and classified in the seven Toyota waste, whereby it was established that the changes with the highest percentage were: defects with 39% and processes with 30%. The following diagnoses were established for the emergency department of the hospital: poor distribution of spaces; lack of inventory in areas such as central nursing, sampling and billing; technological problems; poor communication with the patients; and lack of order in the attention process and support for the patient.

Once the diagnosis was built, a socialization team was created, and it decided that it would intervene in the following areas: admissions, sampling, and billing, excluding consultation, radiological examinations, and reassessment, since it was considered that such processes required long term strategies. However, the waste found, and the long waiting times were socialized with these areas to raise awareness among health professionals for them to improve in such aspects. The recommended strategies that address the problems found in the focus areas were: to study the possibility of having an auxiliary nurse for the sampling area; to define a mechanism to compensate the admissions area; to define a support mechanism for calling patients at billing; to establish a visual identification system of appropriate identification for the patient; to improve loudspeaker audio; to develop a monitoring mechanism and implement continuous improvement teams. These recommendations are in evaluation but the pandemic for the SARS-COV-2 has limited their implementation. The authors plan to report the results as soon as they are available.

The results found in the current research suggest that Toyota's lean methodology is an agile method that is easily adaptable to the needs and / or problems of an institution. This methodology allows to identify the flaws in the care model in a way that engages all actors in the process and enables dialogue and exchange with collaborators who are at the operational level, to reach the root of a problem and attack it from there. This research allowed to recommend the implementation of the lean methodology in the healthcare sector. Specifically, it gave guidelines for an adequate development in the exercise of in-hospital management and the emergency service, determining opportunities for improvement, establishing a team that works under a continuous review methodology and providing short- and long-term strategies.

References

1. Womack JP. Lean thinking. Banish waste and create wealth in your corporation. New York (NY): Free Press; 2003.

2. Weinstock D. Lean healthcare. J Med Pract Manag MPM. 2008;23(6):339-41.

3. Padilla L. Lean manufacturing manufactura esbelta/ágil. Rev Electrónica Ing Prim ISSN. 2010;2076(3166):91–98.

4. Feld WM. Lean Manufacturing: Tools, Techniques, and How to Use Them. Taylor & Francis; 2001. 228 p.

5. Mousavi Isfahani H, Tourani S, Seyedin H. Features and Results of Conducted Studies Using a Lean Management Approach in Emergency Department in Hospital: A Systematic Review. Bull Emerg Trauma. 2019 Jan;7(1):9-20.

6. Toledano de Diego A, Mañes Sierra N, García SJ. «Las claves del éxito de Toyota». LEAN, más que un conjunto de herramientas y técnicas.. Cuadernos de Gestión 2009; 9 (2):113-122.

7. Martínez Sánchez Paloma, Martínez Flores José, Nuño De La Parra Pablo, Cavazos Arroyo Judith. Mejora en el tiempo de atención al paciente en una unidad de urgencias gineco-obstétricas mediante la aplicación de Lean Manufacturing. Rev. Lasallista Investig. [Internet]. 2016 [cited 2022 Oct 25]; 13(2): 46-56. Available from: http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1794-44492016000200006&lng=en. https://doi.org/10.22507/rli.v13n2a5

8. Bohorquez A. Desarrollo de una propuesta de mejoramiento continuo para el servicio de urgencias del hospital universitario de la samaritana (hus), con la aplicación de la metodología *lean healthcare. 2017.* Available from: https://repository.unilibre.edu.co/handle/10901/10592

9. Hernández R, Fernández C, Baptista P. Metodología de la investigación McGraw-Hill. México DF. 2014;

10. Ng D, Vail G, Thomas S, Schmidt N. Applying the Lean principles of the Toyota Production System to reduce wait times in the emergency department. CJEM. 2010;12(1):50-7.

11. Martínez P, Martínez J, Nuño P, Cavazos J. Mejora en el Tiempo de Atención al Paciente en una Unidad de Urgencias Mediante la Aplicación de Manufactura Esbelta. Inf Tecnológica. 2015;26(6):187-98.

12. Van Goubergen D, Lambert J. Applying Toyota production system principles and tools at the Ghent University hospital. En: Industrial and Systems Engineering Research Conference. 2012.

13. Kalong NA, Mohd M. Understanding waste for lean health information systems: a preliminary review. En: MedInfo. 2013. p. 749–753.

Notes

* Artículo de investigación