Study of the Impact of the Process Optimization on Outpatient Service Efficiency Application of Lean Tools

Samantha V. Carpio-Rodriguez[1]; Rafaella X. Pereyra-Cevasco[2]; Rafael Chavez-Ugaz[3]; Claudia C. Leon-Chavarri[4]
[1234]Carrera de Ingeniería Industrial, Universidad de Lima, Lima, Perú
[1]*20200417@aloe.ulima.edu.pe,* [2]*20201612@aloe.ulima.edu.pe,* [3]*rchavezu@ulima.edu.pe,* [4]*cleon@ulima.edu.pe*

Abstract*– The healthcare sector continues to face challenges related to waiting times and inefficient service management affecting directly the efficiency in the outpatient clinics. These issues are frequently linked to poorly structured workflows, limited task distribution excessive waiting times and unproductive service times that affect negatively the service quality and patient satisfaction. To address the challenges, Lean practices have been widely applied, such as queueing method to improve patient flow, workload balancing to prevent staff overload and the standardized procedures to reduce variability. The improvement tools were applied following the DMAIC structure of the Lean Six Sigma methodology, which provided a systematic approach for problem solving and process improvement. In this context, an improvement model was developed by integrating queueing method, workload balancing and standard work, through Yamazumi diagrams and Standardized Operating Procedures, focusing on operational changes that do not require additional resources of high-cost technologies. The proposed model was validated trough scenario comparison using simulation in Arena software. The results showed a 76.38% reduction in cycle time and 92.08% reduction in patient waiting time. The proposed model offers a solution for improving efficiency and patient experience in outpatient healthcare facilities.

Keywords—Queueing Method, Workload Balancing, Standard Work, Waiting time, Healthcare

I. INTRODUCTION

Nowadays, efficient process management in healthcare services is crucial to ensure high quality patient care. Continuous innovation and improved operational efficiency are two important pillars to provide the best service to patients [1]. However, many healthcare facilities, especially in developing countries, still rely on poorly structured workflows that hinder adequate patient care [2].

In the healthcare sector, inefficient management of ambulatory care processes causes long waiting times and reduces the quality of care [3]. The main reasons for process inefficiencies are unproductive waiting times and unproductive service times. To address the former, it is crucial to apply proper patient prioritization to avoid randomness in patient arrival [4]. In addition, improving workflows [5]. and reducing the variability of unscheduled tasks of medical staff can increase productivity and avoid overload, maximizing manpower and minimizing downtime [6]. In terms of service time, several factors contribute to inefficiency. Ensuring quality requires aligning expert knowledge and minimizing errors, starting from agility in service delivery to the duration of each procedure [7]. Most previous attempts to address this issue have included lean healthcare practices, strategies such as increasing medical staffing or implementing high-tech tools. In the scenario analyzed, implementing high-cost technologies or increasing resources is not an option due to budgetary constraints.

Therefore, two techniques will be adopted to address this problem: the application of the queuing method and standard work with workload balancing. The queuing method mainly addresses inefficient queue management and long waits [8]. Increasing the number of workers is not always the solution, as it raises total costs. Studies show that the application of the queuing method can redesign healthcare processes by identifying bottlenecks and optimizing resource allocation. Its application has achieved waiting time reductions between 65.69% and 74.90% [8]. Standard work focuses on the care flow for patients and medical staff. The application of Standard Work reduces errors and ensures quality of service [9]. The findings present a 25% reduction in process transition time without requiring resources and new technologies [9]. Workload balancing is essential to avoid burnout, work stress, absenteeism and decreased productivity. Combining direct and indirect tasks and multiple workload dimensions promotes an active, healthy and productive workforce, which ensures quality service [10].

This study proposes a process improvement to increase the efficiency of outpatient care. The approach will focus on the application of the queuing method to analyze the current flow, identify bottlenecks and propose improvements to optimize waiting times. In addition, standard work and workload balancing will be applied to structure activities and fairly distribute the tasks of the medical staff. The combined use of these tools will streamline the process, reduce inefficiencies and improve the performance of the health service.

II. Literature Review

A. Efficiency improvement in healthcare services

In the health sector, long waiting times are a problem that generates patient dissatisfaction. Previous studies analyzed the efficiency of the model, identifying bottlenecks and patient flow. With the application of the improvements, the results of the scenarios decreased the waiting time (60.0722 minutes) by 0.198%, 1.319%, 2.186%, and so on progressively [11]. Another essential factor is the quality of customer service. A correct assignment of functions reduces the number of activities that do not add value to the process [12]. Furthermore, a study proposed and validated a self-assessment instrument for Lean Healthcare implementation, providing healthcare organizations with a structured method to measure efficiency, identify waste, and support continuous improvement in service delivery [13].

B. Use of Six sigma or queueing theory to optimize waiting times

Emphasized the need of the implementation of tracking systems to control patient flow from registration to discharge is essential to minimize waiting time by up to 34% [14]. Other studies express the need to eliminate bottlenecks and optimize operational processes to improve patient flow [15] [16]. Six Sigma has been used as a tool to improve service quality in the healthcare sector, reducing errors, standardizing processes and increasing patient satisfaction [17]. Similarly, queueing theory has contributed to demand management and process optimization, allowing the efficient allocation of service capacity and showing a reduction in waiting time of between 65.69% and 74.90% [8]. Queueing theory has also been applied to determinate the appropriate capacity required to meet demand and avoid delays in care [18]. Furthermore, integrating queueing theory with Six Sigma has enabled the development of predictive models for optimal staff allocation and resource planning. [19]. In addition, a case study collected quantitative process time data to apply Value Stream Mapping (VSM), which made possible to analyze clinical processes and identify non-value-added activities. This analysis helped visualize the critical points where dead time accumulates, thus facilitating the redesign of processes leading to an improvement of 36.2% [20].

C. Application of Standard Work and Workload Balancing to improve resource management

There is a growing focus on workload standardization in healthcare services. Standard work has been used to minimize errors and improve quality by ensuring uniformity in task execution. Studies identified that variability in care delivery can be reduce by implementing clear, repeatable procedures [5]. This approach has led to proposals for the use of workload balancing tools to balance the supply and demand in the health centers, including task rotations to prevent work overload [12]. The workload balancing technique has also been applied to redistribute work and optimize team performance [6]. Planning work shifts is also an effective strategy to prevent staff burnout was successfully applied in a case study to balance workload [21]. A research proposes the integration of Six Sigma principles with Standard Operating Procedure (SOP) in order to provide clear guidelines for medical staff [22]. This integration has been shown to reduce variability in clinical practices. In one study, SOPs properly assign nursing tasks, standardize work and minimize discrepancies caused by individual habits or experience levels [7].

D. Implementation of the DMAIC cycle in healthcare processes

In previous studies, the DMAIC cycle (Define, Measure, Analyze, Improve, Control), was applied to optimize healthcare processes. It is used to defined process inefficiencies in patient care, measure waiting and service times, analyze delays, improvement workflows through restructuring and proposed monitoring for sustainability [2]. Similary, in another study they address inefficiencies in healthcare technology assessment measured systems performance, analyzed process gaps, implemented improvements through modeling, and applied control strategies to ensure continuous quality enhancement. [23]. Additionally, other research focused specifically on the reduction of patient waiting times through the DMAIC methodology, where process inefficiencies were identified, improvements were implemented, and the results showed a significant decrease in waiting time within hospital settings [24].

III. Methodology

The proposed solution is based on the philosophy of process optimization and efficient resource management in order to improve service performance. To guide the improvement, the LSS framework was selected, specifically the DMAIC cycle, widely used in healthcare to improve patient care processes [2]. In the definition phase, the problem and objectives of the project are defined using a process map [23]. The measurement phase defines the key characteristics and critical parameters of the process by identifying them in a Value Stream Mapping [20]. The analysis phase involves understanding how the collected variables affect service performance. Some studies use Ishikawa diagrams to identify and classify causes [24], but in this model we chose to use Value Stream Mapping to analyze non-productive times and processes requiring improvement.

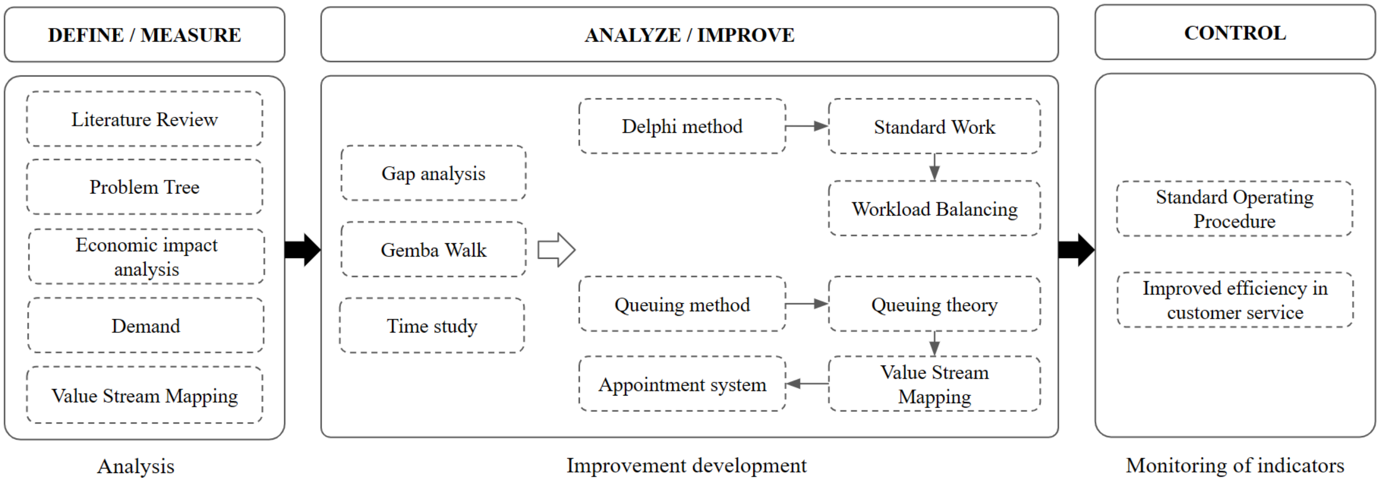

Fig. 1 Conceptual Model

In the improvement phase, the information obtained is used to design and implement process changes aimed at improving service efficiency. The improvement proposal contemplates two main interventions. First, the application of the queuing method focuses on the study of service systems in which entities, in this case patients, experience waiting queues before receiving care in the reception, triage and outpatient areas and, secondly, for the optimization of nursing staff functions, standard work with workload balancing was implemented in order to increase productivity, correctly assigning tasks to the nursing staff and thus avoiding work overload. Finally, the control phase establishes a system to monitor the process over time, through stakeholder feedback and compliance with established KPIs [14].

A. *Define Phase*

The literature collected is evaluated in order to propose a beneficial strategy to address the problem. For this purpose, a comparative analysis of studies was carried out, identifying the tools used. Subsequently, the tools to be used were selected: Queueing method, Standard Work, Workload Balancing and Standard Operating Procedure (SOP).

B. *Measure Phase*

Using the Gemba Walk method, which consists of direct observation of information, patient care flow diagrams were drawn up, specifically for the reception and triage areas, in order to map processes and identify possible bottlenecks, redundancies or inefficiencies.

Time measurements were categorized into six stages: waiting for reception, reception service, waiting for triage, triage service, waiting for admission to consultation and consultation service. Additionally, metrics such as service rate and average arrival rate per hour were determined.

TABLE I
RESUME OF THE COLLECTED DATA

Activity	Average service time (seconds)	Average waiting time (seconds)	Service rate (seconds)	Service rate (per hour)
Triage	165.32	1243.86	6.05E-03	21.78
Consultation	1483.33	7380.09	6.74E-04	2.43
Reception	129.69	916.40	7.71E-03	27.76

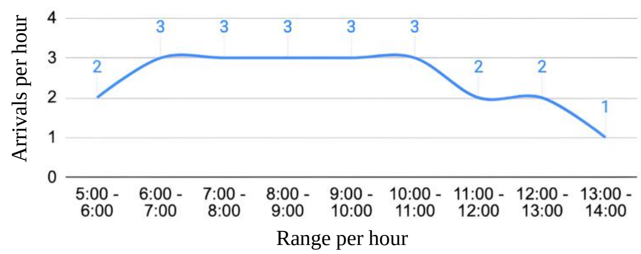

Fig. 2 Average arrivals per hour

To support the performance evaluation a set of key performance indicators (KPIs) were defined.

TABLE II
PERFORMANCE INDICATORS

Indicators	Equations
Cycle time	Total time in the system per patient/patient number
Service time	Total time of care in the system per patient/patient number
Waiting time	Total waiting time in the system per patient/patient number

In addition to process flow time, the average duration of tasks performed by nurses was measured to understand the workload distribution and identify potential inefficiencies. This data was collected through direct observation over the course of one week, recorded times represent the average duration of each task per nurse.

TABLE III
AVERAGE TIME PER FUNCTION FREQUENCY

Functions	Nurse 1 (seconds)	Nurse 2 (seconds)
Equip carts	126.4	66.00
Clinical history from reception to consult	431.85	19.00
Lab to consult	16.80	13.00
Disinfection and cleaning	259.00	164.00
Warehouse resources	371.56	-
Clinical history search	90.67	545.14
Clinical history from reception to triage	22.66	239.60
Clinal history from triage to reception	16.75	221.31
Call answering	323.46	186.00
Clinical history filling	1114.62	1131.54
Total	2773.77	2585.59

C. *Analyze*

VSM was used to evaluated clinical workflows and identify non-value-adding- activities. This tool enabled the identification of critical point where idle time accumulated. [20].

1) Value adding Activity: Activities and process where the patient it is disposed to pay. Consultation service.

2) Non-value adding activity: Adds no value to the patient and can be eliminated or reduced. Waiting time for reception, waiting time for triage and waiting time for admission to consultation.

3) Necessary Non-value adding activity: Activities and process that don't add value from the perspective of the patient but are indispensable for the actual system. Reception service and triage service.

After the analyzation of the whole flow of attention the phase was developed independently for each improvement approach:

1) Queueing Method:

Based on the collected data, arrival rate (λ) and service rate (μ) were computed, allowing for the classification of the system using the M/M/1 queueing model. This model was selected due to it is suitability for systems with single-server, memoryless arrival and service distributions [16]. Process data were analyzed using queueing theory to evaluate each waiting line during the process to identify the bottleneck.

TABLE IV
M/M/1 SYMBOLS AND EQUATIONS

Description	Symbols	Equations
Utilization factor	p	μ/λ
Average waiting time in queue	Wq	$p/(\mu-\lambda)$
Average total time in system	Ws	$1/(\mu-\lambda)$
Average number of patients in queue	Lq	$\lambda^2/(\mu(\mu-\lambda))$
Average number of patients in systems	Ls	$\lambda/(\mu-\lambda)$

The queuing equations presents were applied to the three activities in the patient flow: reception triage and consultation. Each stager was analyzed individually to determinate the respective performance metrics.

TABLE V
APPLICATION OF M/M/1 FOR RECEPTION

Hour	λ	μ	p	Wq	Ws	Lq	Ls
5:00 - 6:00	2	27.76	0.07	0.00	0.04	0.01	0.08
6:00 - 7:00	3	27.76	0.11	0.00	0.04	0.01	0.12
7:00 - 8:00	3	27.76	0.11	0.00	0.04	0.01	0.12
8:00 - 9:00	3	27.76	0.11	0.00	0.04	0.01	0.12
9:00 - 10:00	3	27.76	0.11	0.00	0.04	0.01	0.12
10:00 - 11:00	3	27.76	0.11	0.00	0.04	0.01	0.12
11:00 - 12:00	2	27.76	0.07	0.00	0.04	0.01	0.08
12:00 - 13:00	2	27.76	0.07	0.00	0.04	0.01	0.08
13:00 - 14:00	1	27,76	0.04	0.00	0.04	0.00	0.04

TABLE VI
APPLICATION OF M/M/1 FOR TRIAGE

Hour	λ	μ	p	Wq	Ws	Lq	Ls
5:00 - 6:00	2	21.78	0.09	0.00	0.05	0.01	0.10
6:00 - 7:00	3	21.78	0.14	0.01	0.05	0.02	0.16
7:00 - 8:00	3	21.78	0.14	0.01	0.05	0.02	0.16
8:00 - 9:00	3	21.78	0.14	0.01	0.05	0.02	0.16
9:00 - 10:00	3	21.78	0.14	0.01	0.05	0.02	0.16
10:00 - 11:00	3	21.78	0.14	0.01	0.05	0.02	0.16
11:00 - 12:00	2	21.78	0.09	0.00	0.05	0.01	0.10
12:00 - 13:00	2	21.78	0.09	0.00	0.05	0.01	0.10
13:00 - 14:00	1	21.78	0.05	0.00	0.05	0.00	0.05

TABLE VII
APPLICATION OF M/M/1 FOR CONSULTATION

Hour	λ	μ	p	Wq	Ws	Lq	Ls
5:00 - 6:00	2	2.43	0.82	1.91	2.33	3.83	4.65
6:00 - 7:00	3	2.43	1.23	-2.17	-1.75	-6.50	-5.26
7:00 - 8:00	3	2.43	1.23	-2.17	-1.75	-6.50	-5.26
8:00 - 9:00	3	2.43	1.23	-2.17	-1.75	-6.50	-5.26
9:00 - 10:00	3	2.43	1.23	-2.17	-1.75	-6.50	-5.26
10:00 - 11:00	3	2.43	1.23	-2.17	-1.75	-6.50	-5.26
11:00 - 12:00	2	2.43	0.82	1.91	2.33	3.83	4.65
12:00 - 13:00	2	2.43	0.82	1.91	2.33	3.83	4.65
13:00 - 14:00	1	2.43	0.41	0.29	0.70	0.29	0.70

The analysis revealed that while the reception and triage operate under stable conditions ($p < 1$), the consultation exhibited a system saturation ($p > 1$), confirming it as the primary bottle neck in the process. The instability at this stage invalidated standard queueing metrics, as reflected by negative results in the model outputs.

2) Standard work and Workload Balancing:

In order to determine the characteristics of the patients and analyze the step-by-step job functions of the medical staff, the Delphi method was used with the following structure: problem statement (analysis of the environment and observation of processes), selection of experts, formulation of questions (what is to be understood?) and evaluation of results (basic decision making).

Task analysis was based on the functions of the medical staff described in the Organization and Functions Manual. The selected functions were part of the indirect tasks not pertaining to patient flow. Likewise, additional tasks were incorporated that were observed during the analysis of the flow care. To visualize and validate the task distribution, a Yamazumi diagram was used, providing a graphical representation of each nurse´s workload.

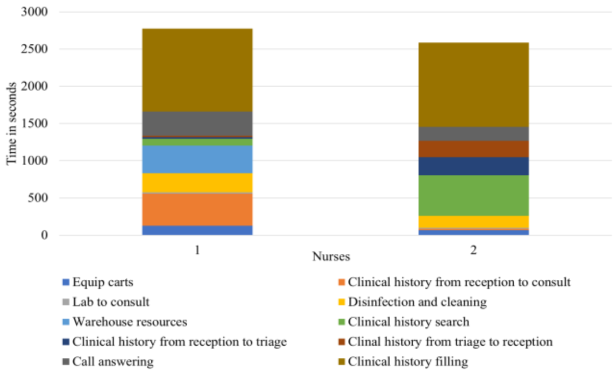

Fig. 3 Yamazumi diagram

The Yamazumi diagram highlighted an imbalance in workload with nurse 1 working in average more time. Task execution appeared to lack defined roles, as both nurses were responsible for almost the same activities, not considering warehouse resources, leading to redundancy and inconsistent task ownership.

D. *Improve*

1) Queueing Method:

As adding additional resources is not a viable option for healthcare facilities with constrained budget, a patient scheduling system was designed to regulate patient arrival times and reduce congestion in the outpatient consultation process. The proposed intervention focuses on redistributing the patient load by structuring appointment schedules to ensure that the arrival rate remains below the service rate during the outpatient consultation stage.

TABLE VIII
RESUME OF THE COLLECTED DATA

Indicator	Value	Unit
Average service time	1483.33	Seconds
	0.41	Hours
Service rate	2.43	Patients per hour
Total patients analysed	22.00	Patients per hour
Analysed time	9.00	Hours
Arrival rate	2.44	Patients per hour
Average time between arrivals	24.60	Minutes
Utilization factor	1.004	-

Although the collected data showed that the arrival rate slightly exceeded the service rate, resulting in a utilization factor of 1.004 and indicating system instability, a staggered appointment system is proposed to improve flow and prevent saturation. Based on the proposed information a daily schedule was developed that includes the morning and afternoon sessions, including the doctor´s break from 15:00 – 16:00. Consultations begin at 9:00 and patients are instructed to arrive 15 minutes earlier for registration and triage. This model accommodates 16 appointments per day.

2) Standard work and Workload Balancing:

Nursing tasks were redistributed based on the goal of balancing task durations and reducing unnecessary moves from one point to another due to different and aleatory tasks. To address this, it was decided to assign each nurse to a specific area for the performance of their duties: nurse 1 was designated to reception and warehouse duties and nurse 2 was assigned to triage and paperwork transfers. Also, considering an additional support from nurse 2 for the filling of clinical history.

The criteria considered to balance the workload was the frequency per function (number of repetitions per day) and the time spent for each task.

TABLE IX
AVERAGE TIME PER FUNCTION FREQUENCY

Functions	Nurse 1 (seconds)	Nurse 2 (seconds)
Equip carts	-	132.00
Clinical history from reception to consult	-	114.00
Lab to consult	-	26.00
Disinfection and cleaning	-	328.00
Warehouse resources	371.56	-
Clinical history search	272.01	-
Clinical history from reception to triage	-	299.50
Clinal history from triage to reception	-	245.90
Call answering	431.28	-
Clinical history filling	1114.62	1131.54
Total	2189.47	2276.94

Following the redistribution tasks, an updated Yamazumi diagram was developed. This visualization reflects the revised task assignment strategy.

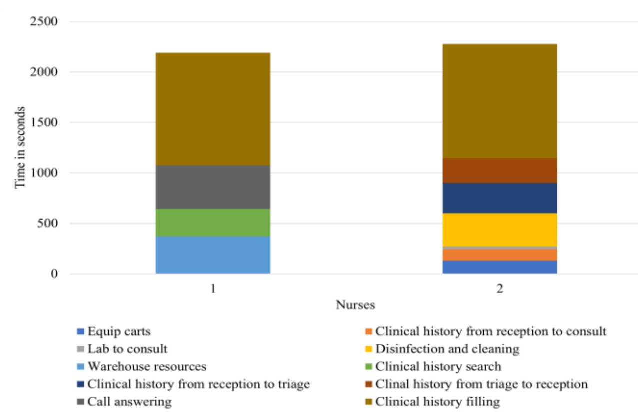

Fig. 4 Yamazumi diagram

As a result, the process flow was reevaluated using updated TO BE diagrams. These new diagrams reflect the proposed improvements to reduce unnecessary nurse movements and balance tasks based on execution time.

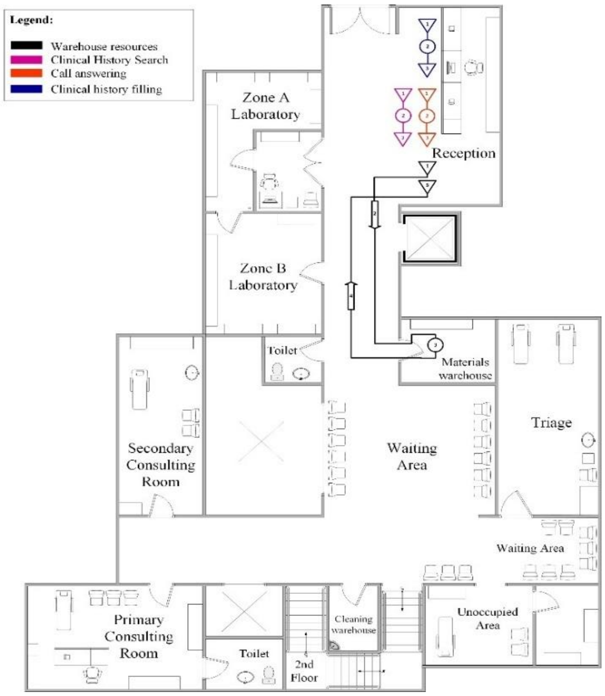

Fig. 5 Flow diagram nurse 1 – TO BE

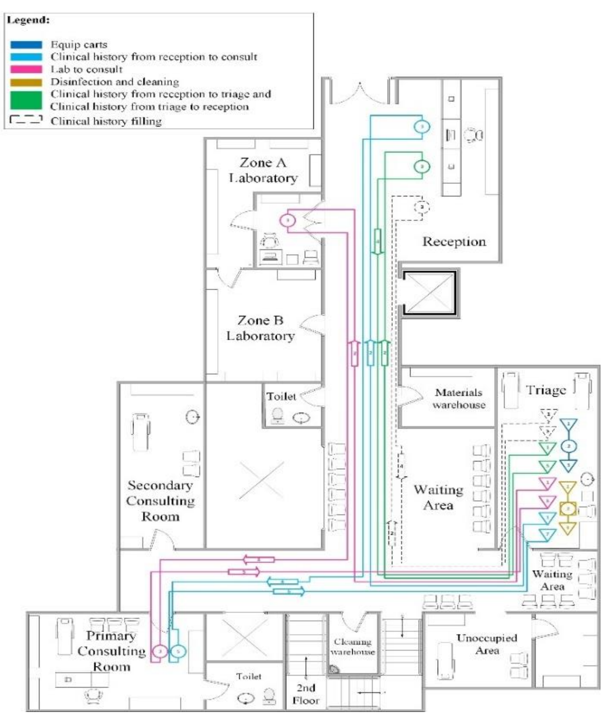

Fig. 6 Flow diagram nurse 2 – TO BE

D. Control

To ensure the long-term sustainability of the proposed improvements, the control stage envisions a structured monitoring plan. It is proposed to track waiting time and cycle time as key performance indicators. In addition, the number of indirect activities performed by each nurse should be evaluated periodically to verify that the new task distribution is maintained and to detect any workload imbalances over time.

Because the appointment system and task redistribution require a cultural shift, the control stage should also include brief training on the appointment system and updated Standard Operating Procedures, feedback meetings to address concerns and highlight benefits, and a short pilot period so staff can experience the new workflow and suggest final adjustments. These steps will help secure commitment to the new processes and support continuous improvement.

IV. RESULTS

The implementation of our integrated model resulted in substantial performance improvements across key process indicators. Most notably, cycle time decreased from 188.64 minutes to 43.46 minutes—a 77% reduction—demonstrating a significant enhancement in overall process efficiency. Waiting time experienced an even more dramatic decline, falling from 159.00 minutes to just 12.21 minutes, representing a reduction of over 92%. Interestingly, service time saw a slight increase, rising from 29.64 to 31.25 minutes. This suggests that some of the efficiency gains were strategically reinvested to enhance the quality of patient interactions, rather than merely accelerating throughput.

TABLE X
COMPARISON OF TIME INDICATORS

Indicators	As Is	To Be	Real
Cycle time	188.64	50%	43.46
Service time	29.64	20.00	31.25
Waiting time	159.00	57.00	12.21

V. DISCUSSION

The average waiting time was reduced from 159.00 to 12.21 minutes, which represents a substantial improvement of over 92%. This result is consistent with findings that highlight the effectiveness of LSS in reducing patient waiting times, especially when combined with other tools [1]. When comparing these results with previous studies, it is evident that the improvement achieved in this research is significantly greater. In a private hospital setting, a reduction of 34% in waiting time was reported after applying Lean Six Sigma and process optimization to improve trauma orthopedic patient flow

[14]. Although both studies were conducted in private healthcare facilities, the initial conditions were different. In the mentioned study, the hospital had relatively structured processes and a specialized patient population, which limited the potential for drastic improvements. In contrast, the clinic presented severe process inefficiencies , lack of structured scheduling and disorganized patients flows, offering a wider margin of improvement.

When comparing this study to research where queueing models were applied in outpatient departments, the waiting time reduction achieved here also surpasses the outcomes reported. In the literature presented, waiting time reduction were between 65.69% and 74.90%. Unlike those studies, which focused exclusively on queueing method, in the presented improvement proposed it is combined queueing method, standard work and workload balancing. The integration of these tools addressed not only patient flow but also nurses workload distribution and task standardization, which likely amplified the magnitude of the improvement observed.

The proposed conceptual model integrates tools that have proven effectiveness individually in previous studies but are rarely applied in combination. Some studies focused on reducing patient waiting times using Queueing theory [16] [25], without addressing workload balancing or work standardization. In contrast, the results of this study demonstrate that combining multiple improvement tools can generate greater effects on process efficiency.

VI. Conclusion

The application of Lean tools, specifically the queuing method, standard work and workload balancing for the reception, triage and outpatient consultation processes allowed the reduction of patient waiting times with the application of an appointment system, as well as the improvement in the quality of care service by health personnel, thanks to the standardization of processes and the balancing of the workload without requiring an increase in resources. The results highlight the efficiency in healthcare services can be improved through low-cost and LSS methodologies, offering valuable alternatives for small and medium sized healthcare facilities.

In terms of performance, the cycle time was reduced from 188.64 to 43.46 minutes, achieving a 76.38% reduction, surpassing the initial expectations. The principal cause of the reduction of the cycle time was the waiting time reduction from 159.00 to 12.21 minutes, effectively addressing the core problem of the patient aleatory arrivals.

Continuing with quality service, the average indirect activity time of the nurses was reduced from 46.23 to 36.49 minutes for Nurse 1 and 43.09 to 37.95 minutes for Nurse 2, optimizing their tasks and transfers thanks to the corresponding assignment described in the Standard Operating Procedure.

VII. Recommendation

Regarding simulation process, it is recommended to use the advanced version of the software Arena, which allows a configuration of more complex and specific appointment calendars for each day of the week. This would allow weekly simulations with differentiated schedules, reflecting better the current operation of the health facility.

It is also recommended to consider the use of more advanced tools, such as algorithms that improve the randomness of the demand. Although during the research it was found that the probability of non-attendance was low, considering it in future analyses would allow a more accurate and realistic simulation, anticipating possible discrepancies.

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