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Service Model Based on Lean Six Sigma and Queuing Theory to Increase NPS in a Healthcare Company

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Abstract

Healthcare providers have often had low levels of patient satisfaction with their service, largely due to their perceived high wait times, which have the consequence of negatively impacting patient perception leading to a rejection of future care, thereby reducing potential future revenue for that provider. To correct this, the Lean Six Sigma methodology was used, a multifaceted process standardization tool based on analyzing the processes related to the operations in question and rejecting those that fail to create value for the consumer and at the same time minimize errors; Queuing theory, a mathematical model that allows predicting and optimizing queues and waiting lines given the number of customers in a system and the ability to meet their needs according to available capacity; and Process Simulation, which offers the possibility of converting real-life scenarios into virtual models, facilitating process predictions for better optimization of resources.

Keywords

NPS, Lean Six Sigma, queuing theory, health sector

1. Introduction

Worldwide, the health sector is one of the most relevant sectors, given that it concerns a universal human right. In line with this, "the World Health Organization (WHO) is the United Nations specialized agency for health, composed of 194 Member States. The WHO works globally to promote the highest attainable level of health for all people, regardless of race, religion, gender, political ideology, or economic or social condition. The mission of the WHO is to promote health, preserve global security, and serve vulnerable populations. Access to affordable and adequate healthcare is a human right, and universal health coverage is a fundamental principle guiding the work of the WHO" (WHO 2020).Around the world, healthcare systems prioritize the goal of improving health and ensuring high-quality care for individuals. This research project focuses on increasing patient satisfaction levels, specifically through the Net Promoter Score (NPS) tool, since measuring patient satisfaction is essential to improving services and establishing strategic objectives for all healthcare organizations, as it reflects significantly on the quality of care processes in the health sector (Kaur et al. 2020).

In Peru, the “current segmented and fragmented health system, lack of investment, and poor resource management produce inefficient services that do not meet the needs of the population, leading to a serious sector crisis. This is reflected in the dissatisfaction of health service users and quality of care problems, which have been widely documented in various research studies in the sector in recent years” (Inga-Berrospi, F., & Rodríguez, C. A., 2019).

Thus, the identified problem is the low level of patient satisfaction in Peruvian healthcare providers. The search for solutions and improvement opportunities to enhance patient experience can be seen in various research studies conducted worldwide. For example, in India, there is pressure to improve patient care quality, safety, and service quality while reducing financial and operational costs. However,

healthcare service centers face long waiting times, low productivity, inefficiency, demotivated staff, and low patient satisfaction (Bath, S., Jiru, A., Gijo, E., & Cudney, E.2019). Another example is a service quality study in four medical units in Mérida, Mexico, which found that users were dissatisfied with the service quality, as none of the evaluated dimensions reached an optimal average. Clients did not receive service as expected and reported that their expectations were rarely met. Regarding overall satisfaction, 32.9% of users would not recommend the unit, mainly due to poor treatment by staff (Morales, M., Madero, J., & Pacheco, L. 2018). Similarly, a study by the Ecuadorian Social Security Institute, using medical units in the cantons of Pasaje and Santa Rosa as a sample, identified deficiencies affecting satisfaction with care quality from the affiliates' perspective, with waiting time being the primary cause (Vite, H., Palomeque, I., & Romero, W.2018).This scientific article is divided into introduction, literature review, methods, data collection, results and discussion and finally the conclusions regarding the stated objectives.

1.1 Objective

The study aims to determine whether the implementation of Lean Six Sigma combined with queuing theory contributes to an increase in the Net Promoter Score (NPS) in a healthcare organization.

2. Literature Review

2.1 Lean Six Sigma in the Healthcare Sector

According to the reviewed research, the Lean Six Sigma methodology in the healthcare sector is a valid continuous improvement tool (Bhat & Jnanesh 2014; Al Khamisi et al. 2018; Peimbert-García et al. 2019; Antony et al.2019; Ordoñez & Quiñones, 2022; Kuiper et al. 2022) which has been successfully implemented in terms of cost reduction (Ahmed et al. 2018; Antony et al. 2019; Kuiper et al. 2021; Ramires & Sampaio 2021; Sohal et al., 2022) and revenue increase (Ahmed et al. 2018). Additionally, patient satisfaction with the provided service was improved as a result of reduced waiting times and faster care (Ahmed et al. 2018; Ordoñez & Quiñones 2022). However, despite the widespread recognition since its inception in manufacturing industries (Antony et al. 2019; Ibrahim et al. 2022), it has a low degree of implementation in healthcare (Bhat et al. 2014; Bhat et al. 2019; Sunder et al. 2020; Ibrahim et al. 2022).

Findings from the literature review range from successful tool implementation (Bhat et al. 2014; Al-Zain et al. 2019; Ordoñez & Quiñones 2022; Kuiper et al. 2022) to guidelines for proper implementation (Bhat & Jnanesh, 2014; Ahmed et al. 2018; Al Khamisi et al. 2018; Antony et al. 2019; Vaishnavi & Suresh 2021; Bhat et al.2019; Vaishnavi & Suresh 2020), including identification of factors related to failure probability (Bhat et al. 2019; Kuiper et al. 2021) and performance improvement (Ahmed et al. 2018; Al Khamisi et al. 2019; Sunder et al. 2020). Consequently, having demonstrated the validity of the technique, it is reasonable to assume that its proper implementation by healthcare providers leads to benefits related to service quality and associated performance, showing increased revenues and cost reduction, not to mention improvements that directly affect patient perception. Therefore, there is sufficient evidence to infer that adopting the Lean Six Sigma methodology leads to an increase in patient satisfaction.

2.2 Queuing Theory in the Healthcare Sector

The examined literature deals with waiting times related to healthcare providers (Green & Soares 2004; Savva et al., 2019; Yaduvanshi et al. 2019; Silva et al. 2021), specifically regarding the uncertainty healthcare providers face about patient arrival times (Yaduvanshi et al. 2019; Safdar et al. 2020) and resource utilization (Safdar et al. 2020; Rodrigues et al. 2022). The role of process simulation as a cost-optimization tool is discussed (Yaduvanshi et al. 2019; Cudney et al. 2018), allowing the analysis of effects of implementing changes (Cudney et al. 2018) and proving very useful for managers (Bittencourt et al. 2018). Similarly, patient satisfaction appears linked to the nature of waiting time (Liu et al. 2019).The analyzed articles serve as guides for proper use of the tool (Green & Soares 2004; Savva et al. 2019). Parameters and metrics on which the model will be built are described (Savva et al. 2019; Silva et al. 2021; Rodrigues et al. 2022) with the aim of identifying the ideal configuration to minimize service cost (Savva et al. 2019; Silva et al. 2021).Since the main problem in the clinic's ambulatory service is delay in care, these findings stand out for their compatibility, serving as a precedent for appropriate system modeling. It is useful to know that, besides its impact on other aspects of care, there is a direct relationship between waiting times and patient satisfaction.

2.3 NPS in the Healthcare Sector

The Net Promoter Score (NPS) has become a key metric for evaluating patient satisfaction and loyalty in healthcare. Below are five articles exploring the application of NPS in this field, along with an analysis relating their findings and conclusions.First, a study by Wolf et al. (2016) analyzed NPS implementation in U.S. hospitals, highlighting its usefulness in measuring patient experience. The authors found that NPS is not only a reliable indicator of patient satisfaction but can also predict the likelihood of patients recommending the hospital to others. This suggests NPS can be a valuable tool to improve service quality and foster patient loyalty.Conversely, Smith and Jones (2018) investigated NPS use in primary care clinics in the UK. Their study revealed that while NPS effectively identifies areas for improvement, its application should be complemented with other metrics to obtain a fuller view of patient experience. The authors argue that NPS alone may not capture all dimensions of patient satisfaction, especially where care is more complex and multifaceted.

In a different context, García et al. (2019) explored NPS use in private hospitals in Latin America. Their research showed that NPS is particularly useful for comparing performance between institutions and identifying best practices. However, they also noted that NPS interpretation may vary culturally, suggesting the need to adapt the metric to regional particularities.Another relevant study by Lee and Kim (2020) examined NPS application in specialty clinics in South Korea. They found NPS effective for measuring patient satisfaction in highly specialized services such as oncology and cardiology. However, they also noted the metric may be less effective in services where the doctor-patient relationship is longer and more complex, such as psychiatric care.

Finally, a recent study by Martínez et al. (2022) analyzed NPS use in public hospitals in Spain. The authors concluded that NPS is a useful tool for assessing patient satisfaction in high-demand, resource-limited settings. However, they also cautioned that NPS results should be interpreted carefully as they can be affected by external factors, such as public perception of the healthcare system.In conclusion, these studies demonstrate that NPS is a valuable metric for measuring patient satisfaction and loyalty in healthcare. However, its use should be complemented with other metrics and adapted to each institution's and region's specific context. It is also important to consider NPS limitations, especially in complex, prolonged care settings. Overall, NPS can be a powerful tool to improve service quality and foster patient loyalty when used appropriately and critically.

3. Methods

The healthcare sector is very important worldwide as it is a direct provider of the universal right to health. Despite its high relevance, the Peruvian healthcare sector shows high patient dissatisfaction due to high costs, unnecessary delays (waiting in lines, pharmacy delays, delays in scheduled appointment times), among others. Therefore, improving healthcare services to create a positive patient experience generates a competitive advantage both nationally and internationally, and will benefit the company because a high NPS will generate more promoters and thus a greater number of visits and revenues. Considering this need in the healthcare sector, the literature review identified Lean Six Sigma as the most appropriate methodology to solve the identified problem, and the implementation of Queuing Theory will optimize the strategy.The proposed model is based on the implementation of the Lean Six Sigma philosophy with Kaizen, Poka Yoke and Value Stream Mapping (VSM) tools, in addition to the implementation of queuing theory. The model proposed in Fig. I shows that 5 components will be developed, explained in detail below:

Component 1: Define

For this component, flowcharts are required for a step-by-step understanding of this service, for which workers in the Ambulatory Admission area will be consulted to collect the data to assemble it. Likewise, a VSM will be built to identify activities that do not generate value. From this, it will be possible to define which variables, objectives, and indicators (KPIs) will be evaluated.

Component 2: Measure

The data of the NPS survey will be collected, with it and with the opportunities for improvement detected in the VSM, the defined indicators (KPIs) will be generated. Likewise, the data of the queue times that the patient takes will also be collected and analyzed, from it. In addition to the generation of indicators, graphs will be made of the collected data.

Component 3: Analyze

With the data collected from the NPS survey, the most important KPIs for the company will be analyzed in depth. The identification of the most important problems and indicators for this will be carried out using a Pareto chart. In this way, the most frequent reasons that cause an inadequate customer experience will be identified. Similarly,

with the data collected from queue times; and will analyze the generated KPIs. Histograms will be generated to have a visual representation.

Component 4: Improve
With respect to the Kaizen tool, a culture of continuous improvement will be created in which the employee can identify and communicate opportunities. The methodology applied above is closely related to the 5S since it seeks to improve the order and cleanliness of the workstation. It will be applied mainly to virtual documents, determining the purpose of the tools, organizing the required data facilitating its obtaining or visualization and performing constant maintenance to the equipment. The standardization of the new measures will be sought. In addition, it will seek to limit the adverse situations that may arise by updating the contingency measures that are in place.
With respect to the Poka Yoke methodology, this will be used to identify those errors that normally owe their existence to carelessness and implement measures to prevent them. It will be used to digitize storage, thus avoiding errors linked to its physical storage. With all this, it will be possible to reduce activities that do not generate value. In addition, the application of queuing theory will begin, to have an overview of relevant issues in the attention queues.

Component 5: Control
Once the improvement solutions have been implemented, constant monitoring and control will be carried out to evaluate the proposed objectives and be able to compare the situation of the case after the implemented proposals with the initial situation. In this way, the effectiveness of the selected methodologies can be evaluated. This will be done through the supervision of compliance with the proposed standards, a monitoring plan, and dashboards will be generated with the selected KPIs to have a daily representation of their evolution.

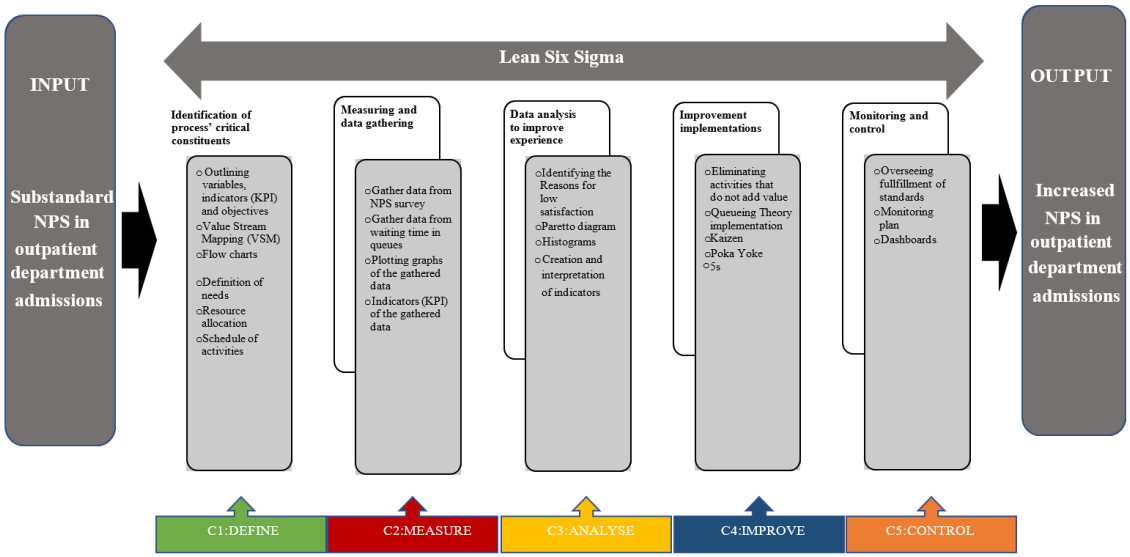

Figure 1. Proposed model

4. Data collection
Data for this study was collected through a combination of direct observation, staff interviews, and patient satisfaction surveys in the Ambulatory Admission area of Clínica SANNA El Golf. Flowcharts and a Value Stream Map (VSM) were developed using input from clinic staff to visualize current service flows and identify non-value-added activities, such as patient waiting times. Additionally, four key performance indicators (KPIs) were defined: Net Promoter Score (NPS), queue waiting time, staff utilization, and service time. NPS data was gathered through patient surveys. The main causes of service dissatisfaction were identified through Pareto analysis, guiding the selection of Lean Six Sigma and queuing theory tools for process improvement. Bibliographic sources also supported the methodological framework and tool selection throughout the research.

4.1. Indicators
In this present research work, the following indicators will be used:
a) Net Promoter Score

It allows the measurement of the customer experience and to what extent they would recommend the service. The goal is to approach the standard of 58.

$$Net\ Promoter\ Score = \%Promotors - \%Detractors$$

b) Waiting time in queue

It allows the measurement of the time that a patient spends waiting for their turn to be attended at the counter. The goal is to reduce it by 10%

$$Time\ in\ queue = Time\ of\ arrival - Time\ of\ ticket\ delivery$$

c) Utilization of staff

It allows the measurement of the saturation of each administrator during the attention process. The goal is to approach the range between 60% and 80%.

$$Utilization\ of\ staff = \frac{Mean\ time\ spent\ in\ attention\ by\ employee}{Mean\ total\ time\ working\ by\ employee}$$

d) Attention time

It allows the measurement of the time that an average attention lasts. The goal is to reduce it by 20%

$$Attention\ time = Beginning\ of\ attention - End\ of\ attention$$

5. Results and discussion

5.1 Validation

Validating the model requires two modalities: pilot and simulation. The tools relevant to the Lean Six Sigma methodology need a pilot test to assert the feasibility of their implementation. The simulation of the model, in addition to quantifying its performance, will verify the impact of queuing theory on attention.

a)Initial diagnosis

When the initial analysis of the situation in the company was carried out, it was observed that the main problem identified was the low valuation in the Net Promoter Score indicator in the ambulatory admission area, this was far from the value of the standard sector, since it presented an NPS of 37.4, 20 points below. The main causes found are the delay in attention and the lack of attention counters. The results of the application of the model proposed in this article are presented below, together with the measurement of the indicators.

b) Validation design and comparison with initial diagnosis

The pilot test described took place in November, a period during which 16,297 patients were attended at the outpatient department. Its quantitative results were analyzed together with the information regarding the opinion of a sample of 1,045 surveyed patients to evaluate its relevance in the face of the uncertainty that may be present in a service constituted by a distinctive variety of activities.

The variables considered in the queuing theory model were care times, number of patients, number of administrators, cost per administrator, and cost of an unsatisfied patient. Optimize resources using this model and Lean tools, as well as standardization of processes associated with Six Sigma, provides the possibility of providing better care at a lower cost leading to an increase in profits.

c) Simulation of the proposed model

Excel was used to create the queuing theory model, which was validated together with the improvements belonging to the pilot test through a simulation in the Arena software as can be seen in Fig. 2 to measure the improvement exhibited in the system. After adjusting the parameters according to the collected data, the following results were obtained.

Table 1. Comparative matrix of indicators for measuring improvement

Indicator	**As Is**	**To Be**	**Simulation / Pilot**	**%**
Net Promoter Score	48.4	58	51.2	6%
Waiting time in queue	1.89 minutes	1.7 minutes	0.52 minutes	-72%
Utilization of staff	84%	70%	76%	-8%
Attention time	7.5 minutes	6 minutes	7 minutes	-7%

A positive performance was achieved in all indicators, even exceeding the expected value in the reduction of the waiting time in queue, which was reduced from 1.89 minutes to 0.52 minutes.

6. Conclusion

This research managed to provide an in-depth overview of some challenges faced by health providers, and how they can be addressed.

By implementing quality tools such as the Lean Six Sigma framework, it is possible to increase the performance of resources in the desired operations thanks to a reduced number of errors and a better utilization of these resources. In this case, the average attention time was reduced from 7.5 minutes to 7 minutes, a reduction of 7%.

The Queuing Theory tool has proven its usefulness in the analysis of the tail of a system, presenting key information in the decision making of operations. In this case, thanks to the information discovered, the decision was made to simulate the system with greater resources, bringing positive results. A 72% reduction in wait time and 8% reduction in staff utilization, plus reductions in queue length, probability of waiting and probability of finding the system occupied are testimony to this statement.

Considering the nature of the improvements implemented, there is sufficient reason to consider that the tools implemented may have a similar effect on other front office processes of the clinic, because although they escape the focus of this article, they do not differ greatly from the topics covered.

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Biographies

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Martin Collao-Diazat ESAN University and Industrial Engineer from Universidad de Lima specialized in supply chain management and operations. A leader with more than 25 years of local and international experience in national and multinational companies in industrial, hydrocarbon, and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport, distribution and warehouse management), operations (planning and control of production and maintenance), and integrated system management (ISO 9001, ISO 14001, and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Furthermore, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology, among others, focused on being a High-performance Organization (HPO). Development of a high-performance team. Member of IEEE and CIP (College of Engineers of Peru).