

# Reduction of Average Lead Time in Outpatient Service of Obstetrics Through Six Sigma Methodology

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**Abstract.** In hospital services, operations efficiency and healthcare quality are two critical factors since both define the financial sustainability of the hospitals as well as patient health, safety and satisfaction. For this reason, it is necessary to explore different strategies for the improvement of quality and efficiency indicators in the provision of healthcare services. Specifically, this paper focuses on the application of Six Sigma methodology as an important option to solve this problematic. This methodology begins with the identification of improving opportunities that are aligned with the organization goals. Then, a portfolio of potential improvement projects is created. Later, these projects are prioritized with basis on multicriteria decision making techniques, with the purpose of choosing the project with the highest impact on the organization quality and efficiency. Finally, the selected project is developed through DMAIC cycle. An application case related to the process of obstetric outpatient in a maternal-child hospital located in the city of Barranquilla (Colombia) is presented to prove the validity of the proposed approach. The results show that the average lead time in the obstetric outpatient service in which pregnant women are monitored, was reduced from about 7 days/appointment to approximately 4 days/appointment.

**Keywords:** Average lead time · Six sigma · Obstetric outpatient · Healthcare quality

## 1 Introduction

Currently, healthcare organizations face two main challenges. The first challenge is referred to the reduction of the high costs related to the inclusion of advanced technology and new medical treatments for diagnosis and intervention processes. Second, the growing demand of services with high quality standards and patient safety that implies having an adequate staff, medical equipment and processes [1, 2].

To provide a safe, quality and low-cost healthcare service, hospitals and clinics must have efficient processes, trained and committed staff, advanced technology and a strategic platform that integrates these aspects effectively.

In last decade, Six Sigma has become in a successful strategy for those organizations that want to achieve operational excellence, get high standards of quality and reduce non-quality costs in order to be more efficient and become in world-class companies. The healthcare sector is not the exception, and despite Six Sigma was initially focused on production contexts, many healthcare organizations have implemented it as a strategy to reduce operation costs and process inefficiencies, increase service levels, make administrative processes more efficient, diminish medical errors and make good use of installed capacity [3].

This work explains the methodology and presents the results of a Six Sigma project implemented in a maternal-child hospital whose primary aim was to reduce the lead time in the outpatient service of its obstetric department. The results show the effectiveness of Six Sigma methodology to achieve meaningful improvements in services provision.

This paper is organized as follows: Sect. 2 briefly presents a background related to Six Sigma applications on healthcare services. Section 3 presents the proposed methodology for the effective implementation of Six Sigma in care processes of clinics and hospitals. Section 4 provides the activities and results of execution phase of this methodology in a study case. Finally, conclusions about this research work and suggestions for further research are made in Sect. 5.

## 2 Literature Review

There are multiple applications of Six Sigma methodology on the quality and productivity improvement in hospital sector. The first implementation case of Six Sigma in healthcare sector has been registered in The Commonwealth Health Corporation in 1998. Some achieved results are the increase of 33 % in throughput, a cost reduction of 21.5 % in radiology; also savings of US\$2.5 million were achieved [4].

In the United States, “Mount Carmel” healthcare system, a set of 3 hospitals located in Columbus (Ohio) that has 7300 employees and a staff of 1200 doctors in different specialities, had a financial state that was experiencing a crisis that threatened the stability of the company. Given this, the directors of this organization decided to implement Six Sigma methodology since guaranteed a significant and continuous benefit projection in time. This decision meant a return of \$3.1 million of dollars with increasing expectations; moreover, dissatisfaction level and staff frustration were also reduced through meaningful operational improvements [5].

Another large-scale application case of Six Sigma was presented in The Red Cross Hospital in Netherlands. Between 2002 and 2004, 116 people were trained in Green Belt level and about 70 projects were developed. The results showed a total saving of €1.2 million at the end of 2004. Some of the projects were: Improving patient scheduling operating theatre Reducing accounts receivable; Optimizing technical maintenance; Reducing formation of physiotherapists Revision of terms of payment; Reducing admission time hip replacement Reducing admission time after delivery; Improving logistics linen distribution; Availability ambulatory files; and Reducing waiting times first contacts cardiology [2–6].

### 3 Methodology

For a successful implementation of Six Sigma methodology, it is necessary to take into account a series of factors such as: project articulation with organization goals, manager commitment, Six Sigma training, the conformation of a team for project development, the selection of key projects, among others [7–10]. Therefore, prior to developing any Six Sigma project, it is fundamental to consider the factors mentioned above with the aim of increasing the success probability at the moment of implementation. The present proposed approach is constituted by 4 phases (See Fig. 1) as it is shown below:



**Fig. 1.** Methodology for the effective implementation of Six Sigma projects

- **Phase 1- IDENTIFICATION:** To identify key improvement areas, it is necessary to analyze three aspects in any organization: Voice of customer (VOC), strategy goals and organization policies and the processes together with the key performance indexes (KPIs). The voice of customer analysis is done by the identification of critical to satisfaction (CTS). For this, a survey was designed and carried out with the aid of Health Service Companies (customers) which point out the most relevant quality characteristics in the provision of hospital services. After obtaining customer perceptions, organizational policies, goals and their importance and key performance indexes are defined. KPIs should be definite in terms of a current and future state with the purpose of evaluating the effectiveness of the Six Sigma projects that will be finally selected for their implementation.
- **Phase 2 – ALTERNATIVES:** The creation of Six Sigma project alternatives is done by linking each organizational goal with the different improvement points detected in VOC analysis, generating a Six Sigma project portfolio that is coherent and measurable with respect to the organization goal and current market. In this case study, these project alternatives were identified: Improvement of average lead time in Outpatient service of Obstetrics, Improvement of average lead time in Outpatient service of Internal Medicine, Improvement of User Information System, Improvement of Information System opportunity, Improvement of average lead time in Emergency Department and Optimization of Inventory System.
- **Phase 3 – PRIORITIZATION:** The Six Sigma project selection process consisting about evaluating a project portfolio, and then choosing the implementation

of one of them so that organization goals are achieved [11]. It is one of the most critical stages of a Six Sigma process since it defines a great part of project success [12]. Therefore, it is important to guarantee that projects are selected in line with the healthcare organization goals and objectives [13]. In this study case, a hybrid multicriteria decision technique called ANP-DEMATEL was used. This technique has been successfully employed in project selection and is based on pairwise comparisons of the importance and influences [14].

In the evaluation process, four criteria were defined: OPPORTUNITIES, BENEFITS, RISKS and COSTS. Each criterion was divided in sub-criteria until completing a total of 15 sub-criteria. Additionally, three strategic objectives were defined: BUSINESS EXCELLENCE, INCOME GROWING and PRODUCTIVITY. To evaluate the selected projects, a decision team was conformed and the final decision consisted about implementing the project: IMPROVEMENT OF AVERAGE LEAD TIME IN OUTPATIENT SERVICE OF OBSTETRICS.

- **Phase 4 – EXECUTION:** Finally, the selected project was developed through DMAIC CYCLE which is the main focus of this paper. In the next item, the activities and results of each DMAIC stage are detailed.

## 4 Execution Phase: Improvement of Average Lead Time in Outpatient Service of Obstetrics

### 4.1 Define Phase

In this case study, the define phase evaluates the performance of average lead time in outpatient service of Obstetrics from a maternal-child hospital located in Barranquilla (Colombia). In this phase, several employees from Quality Department, Financial Department, Outpatient Department and User Support Department were teamed up in order to have a clear project definition. To define the current state of average lead time in outpatient service of Gynecobstetrics, a line diagram has been used (See Fig. 2). This figure shows that in some months (September, March and April), the lead time was greater than the upper specification limit (8 days/appointment) given by the Ministry of Health and Social Protection of Colombia. The greatest lead time was 9.33 days/appointment and took place in April.

The above mentioned situation results in a more extended waiting time for pregnant women before being served. This increases the risk of complications during pregnancy since doctors will only be able to detect anomalies (in case of the patient have them) of these patients lately. This means that a new life can be put in danger. With this information, a project charter was designed. In it, six months were established as the duration of the Six Sigma project. On the other hand, to clarify the process of Obstetrics outpatient service, a SIPOC (Supplier – Inputs – Process – Outputs - Customers) has been designed (See Fig. 3).

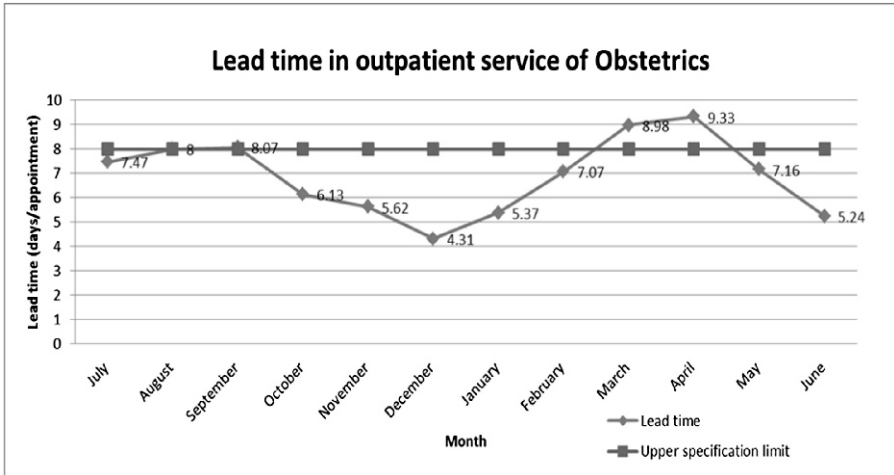


Fig. 2. Lead time in outpatient service of Obstetrics from maternal-child hospital in study

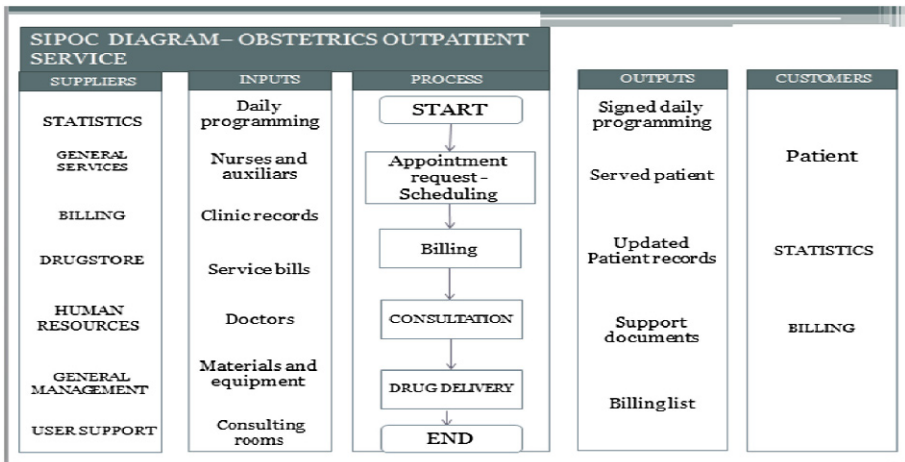


Fig. 3. SIPOC diagram for Obstetrics outpatient service

### 4.2 Measure Phase

In measure phase, the robustness of the process is evaluated with respect to the upper specification limit through a process capability analysis and the calculation of current sigma level, defects per million of opportunities (DPMO), process efficiency and process error (See Table 1):

Table 1 illustrates that the current process has a very low sigma level (0.71). The sigma level range is 0–6 where 0 is the worst state and 6 the best. This means that out of 1000000 appointments, 322800 will have a lead time greater than 8 days/appointment. On the other hand, this process registers an efficiency of 67.72 % which is low and

**Table 1.** Six sigma indicators for Obstetric outpatient service

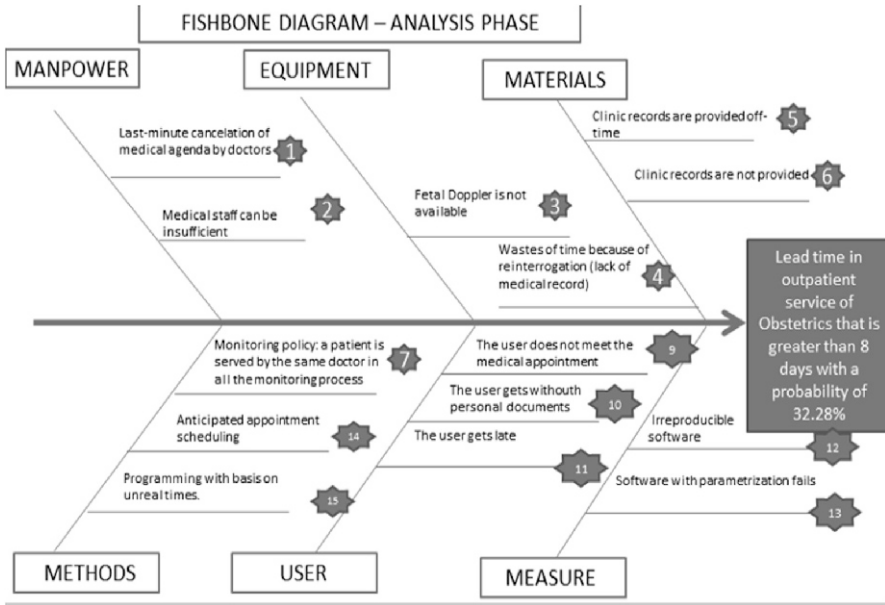
<b>USL</b>	8	<b>DPMO</b>	322800
<b>LSL</b>	0		
<b>Mean</b>	6.89		
<b>UCL</b>	11.612	<b>Sigma level</b>	0.71
$\sigma$	1.574		
<b>Zu</b>	0.71		
<b>P(Zu)</b>	32.28 %		
<b>P(error)</b>	32.28 %	<b>Cps</b>	0.235
<b>Efficiency</b>	67.72 %		

reflects a primary need of intervention. This is confirmed at the moment of seeing that the probability of overpassing the upper specification limit is equal to 32.28 % which is considerable. Finally, it is seen that the process has a Cps equal to 0.235 which means that the process is not capable to meet the requirements demanded by the Ministry of Health and Social Protection. It is necessary to remark that the measure system composed by the operators of APPOINTMENT SCHEDULING DEPARTMENT and the support software used by the hospital was validated to guarantee reliable data.

### 4.3 Analyze Phase

The measure phase displayed the current performance of the Obstetric outpatient service, showing that its performance level is unsatisfactory with need of urgent intervention. The root causes that impacts this process have to be identified and analyzed so that improvement processes can be done in the correct points, actors or interactions that exist in it. For this reason, a cause and effect diagram was drawn in order to determine what factors contribute to the fact that the lead time overpasses the upper specification limit with 32.28 % of probability (See Fig. 4).

The cause and effect diagram (Fishbone diagram) in Fig. 4 reveals meaningful and insignificant causes. The six-sigma team analyzed each possible cause and determined that last-minute cancellation of medical agendas affected the process lead time. Besides, this causes an average extension in the waiting time corresponding to 8.12 days/appointments which impacts negatively on lead time. By the other side, a sub-specialty called *perinatology* is affecting with a correlation coefficient of 0.5459 which becomes in the main improvement point for intervention. This sub-specialty is served by just one doctor with a serving frequency of two mornings (8 am – 12 m) in a week while the rest of the time is in charge of diverse functions that can be assumed (some of them) by a gynecologist. This sub-specialty is in charge of serving women with high-risk pregnancies and in some cases the appointment lead time is equal to 21 days. On the other hand, anticipated programming of appointment requests with a programming date equal to 3 weeks or more (control appointments) also impacted negatively on lead time. Another cause that has to be taken into account is how clinical records are being delivered to all of the doctors of this specialty. It is good to remark that a lack of clinical record could cause an appointment cancelation; reason by which,



**Fig. 4.** Fishbone diagram for lead time in outpatient service of Obstetrics with value greater than 8 days/appointment

this event was measured by the Six Sigma team, obtaining a delivery efficiency equal to 80.58 % which is not sufficient in healthcare services; even though it is known that information flows determine the correct decision making during intervention and diagnosis processes.

#### 4.4 Improve Phase

This phase focuses on reducing average lead time in outpatient service of Obstetrics from a maternal-child hospital. The condition of improvement is achievable though the implementation of some new policies and support software. With respect to the sub-specialty of *perinatology*, the project black belt together with the chief executive of the hospital decided to increase the installed capability of this sub-specialty so that, a high impact on the lead time of obstetrics outpatient service can be observed. For this, it was fundamental to analyze the functions of this doctor in order to verify if some of them can be reassigned to gynecologists. The analysis made recommended to reassign functions that were developed in mornings. In this way, this doctor was enabled to serve patients every day mornings. It is good to highlight that this kind of sub-specialty is not common in our country, reason by which it is difficult to hire another specialist. This fact is very delicate because directly affects women with high risk of losing their babies.

On the other hand, software for registering electronic clinic records was implemented since these records were delivered physically. This avoids wasting time looking for

records in a clinic record room, interrogating patients during consultation and calling off appointments.

By the other side, the hospital decided to fine doctors who get late and cancel appointments at the last minute. If there is an absence, the Outpatient Department must verify if the excuse given by doctors is valid. This was subject to contract that the hospital has with an association of gynecologists. Finally, the scheduling of appointments with too much anticipation with respect to the requested programming date was restricted to 1 week of anticipation.

After the intervention, the indicators were recalculated. Table 2 illustrates that the current process has a better sigma level (3.16). This represents an increase of 2.45 sigma. This also means that out of 1000000 appointments, 46500 will have a lead time greater than 8 days/appointment; which indicates a reduction of 85.59 %. On the other hand, this process registers an efficiency of 95.35 % which represents an increase of 27.63 %. This is confirmed at the moment of seeing that the probability of overpassing the upper specification limit is equal to 4.65 % which is low. Finally, it is seen that the process has a Cps equal to a.054 which means that the process is capable to meet the requirements demanded by the Ministry of Health and Social Protection. On the other side, the operational cost by consultation was reduced in 12 % thanks to the intervention.

**Table 2.** Six sigma indicators for Obstetric outpatient service

<b>USL</b>	8	<b>DPMO</b>	46500
<b>LSL</b>	0		
<b>Mean</b>	4.08		
<b>UCL</b>	7.8	<b>Sigma level</b>	3.16
<b>Σ</b>	1.24		
<b>Zu</b>	3.16		
<b>P(Zu)</b>	4.65 %	<b>Cps</b>	1.054
<b>P(error)</b>	4.65 %		
<b>Efficiency</b>	95.35 %		

#### 4.5 Control Phase

In this phase, it is necessary to maintain the achieved benefits. For this, it is essential to create strategies that permit a correct quality control and monitoring with the purpose of taking preventive actions before the probability of overpassing the upper specification limit (USL) gets increased. To achieve this, a control chart was designed to monitor the behavior of the lead time for Obstetrics outpatient service with a weekly frequency with the purpose of guaranteeing faster reactions in case of a reduction of sigma level. On the other hand, flowcharts from Quality Management System were updated with new policies and implementation of the software for clinical records. The six-sigma team should continue working on increasing the sigma level with the purpose of guaranteeing a sustainable quality perception by patients.



## 5 Conclusions

This paper focused on deploying Six Sigma through a four-phased methodology from the identification of improving opportunities to the implementation of DMAIC cycle. An application case related to the process of outpatient service of Obstetrics in a maternal-child hospital has been explored. The results prove the effectiveness of the proposed approach. The hospital achieved an increase of more than 2 sigma levels in just 6 months and a cost reduction of 12 %. With these results pregnant women will have shorter waiting times for a consultation, which reduces the risks of losing their babies. On the other side, this reduces the probability of requesting more complex services like hospitalization and emergency because it is possible to detect anomalies earlier reason by which, the recommendations and treatments indicated by the doctors will be more effective on patient's health. By the other side, it is also demonstrated that a correct selection of improvement projects has an important influence on its success due to it is related to organization goals and customer requirements. The hospital in study received a high impact on its market image, financial status and operational conditions since its primary aim is linked to maternal and child diagnosis and intervention.

This framework will guide practitioners and decision makers in healthcare services to obtain better results at the moment of intervening processes related to outpatient service in Obstetrics. For future work, it is recommendable to explore the implementation of the current methodology in other healthcare services and consider more decision variables.

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