

Application of the Operating Room Effectiveness indicator (ORE) in a Brazilian hospital

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Abstract Operating Rooms are important operations for any hospital, being great cost and revenue generators. In this sense, the focus on efficiency is necessary and, in this context, the ORE indicator is raised as an opportunity for studies of efficiency in surgical effluxes. This study applied the ORE indicator in a large Brazilian hospital for one year according to data from the hospital's information system and thus obtained a result of 60.4% average efficiency. In addition to the indicator calculation, improvements were implemented with a focus on scheduling, setup, cancellations, physical organization and material management. According to the comparative with other applications, it is inferred that the efficiency of Operating Rooms in Brazilian hospitals is between 50% and 60%, with great opportunities to leverage surgical productivity.

Keywords: Lean Healthcare, Operating Room, Indicator, Hospitals, Operations Management.

1 Introduction

The healthcare services are essential for the society, however they always have to face with the demand bigger than resource capacity, especially in public sector [1] [2]. At the same time, they need to improve the quality of care and provide more value to patients [3] [4]. In the face of these challenges, over the last decade, many health services have adopted the Lean philosophy to improve the quality and efficiency in the patient flow processes [5] [3] [6].

This philosophy is called “Lean Healthcare (LH)” that emerged as a strategy to eliminate or reduce the activities that does not add value to the patients [1]. The Lean is from the Toyota Production System (TPS), a famous production system because of the efficiency and quality shown in Japanese automotive companies [7]. The concept of lean reached the health services in the early 2000s [8] [9]. In a literature review of [4] is presented that LH has been studied and implemented for many purposes and in multiple healthcare settings in both inpatient care and ambulatory. In this study will be presented the application of a performance indicator for measure the surgical center’s efficiency.

The Operations Rooms (ORs) in the surgical centers are critical unities in a hospital management [10]. They are directly related to the larger function of a hospital production system, which is the intervention to restore the patient's health. They represent a large part of the hospital income and costs [11] [12] [13]. Also, ORs have a complex environment where the tolerance for mistakes is extremely low [13] and they

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can have a limited capacity to the number of available ORs, materials, human resources and equipment [11]. In this context, it is essential to develop works that shows how to improve and analyze the OR's efficiency.

Thus, the purpose of this paper is to analyze the efficiency of Operations Rooms of a Brazilian hospital by means of the indicator "Operating Room Effectiveness (ORE)". This indicator was proposed by Souza et al. [10] for hospital Operating Rooms (ORs), adapted from the OEE (Overall Equipment Efficiency), to measure performance and identify losses based on lean healthcare principles.

The paper is organized as follows. First, we present a brief theoretical background, describing about Lean Healthcare and Operating Room Effectiveness (ORE). Subsequently, we discussed our findings. In the last section, we highlight the main implications and we propose future research.

2 Theoretical Background

2.1 Lean Healthcare

Lean has been applied to various industries and is conceptually described as "an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability" [14].

This methodology is not simply a manufacturing technique to reduce waste and costs, but a philosophy that is applied in any type of organization and depends on several factors to achieve satisfactory results. Healthcare institutions are complex and have many processes that can be improved with the use of the tools proposed by Lean Healthcare [15].

Lean Healthcare is philosophy based on a set of concepts and practices that improve the way hospitals are organized and managed. In a Lean hospital it should aim eliminate mistakes, reduce costs and optimize the layout. In short, Lean is a methodology that enables hospitals to improve patient care quality, support employees, eliminate barriers and focus on providing care. LH also helps overcome barriers between disconnected departments, allowing different departments to work better together to benefit patients [1].

It is important to understand that managers of healthcare services have to manage the wastes and improving the patient flow, in that way LH becomes very important when discuss the efficiency of the ORs [10] Also, it is important aspect for the lean methodology the measurement of performance of the improvements implemented [16]. In the next section explain the indicator ORE proposed by Souza et al. [10].

2.2 Operating Room Effectiveness (ORE)

The maximizing of the ORs efficiency is essential for the hospital because they are the financial nexus of the modern hospital, accounting for up to 40% of a hospital's costs and 60-70% of revenue. There are many factors that can influence in the OR efficiency, like the human resources, infrastructure, materials, limited availability and application of information technology, schedule variation, variety in type of patient, operations and procedures and impaired process flow [11] [13].

To improve the results of the ORs and get a good income for the hospital is essential to manage the ORs efficiency. In literature, like showed for [13], there some examples of measures of OR efficiency like off-hours surgery, same-day cancellation rate, OR use, first case start-time accuracy, turnover time and others. For this work, it will be used the indicator proposed for [10] that consider more than one factor, the indicator is called ORE - Operating Room Effectiveness.

The ORE indicator was proposed for [10] as an adaptation of the OEE (Overall Equipment Effectiveness) to measure the efficiency of the Operating Rooms. The OEE is comes from the industry to measure the efficiency of a manufacturing system and is associated with the program Total Productive Maintenance (TPM) and is a function of availability, performance and quality rate [17]. The availability is

the is the ratio between the time of the equipment is actually available out of time that should be available, the performance is related with the proportion of the number of produced items in a given of time, and quality represent the rate of products within quality specifications out of total produced [18].

In [10] is highlighted that the main difference between these two indicators is because of the focus of ORE on the surgical flow and its specifics characteristics. In that way, the ORE proposed by the authors consider the same structure of the OEE: availability, performance and quality. Also, it is important to empathise that [10] inspired the ORE calculation from [19].

Thus, in the same way that the OEE the ORE can be obtained by the product of the Availability, Performance and Quality indicators or by the fraction between the measures: the Total Time of Added value (TTAV) and Total Time Available (TTA) measures. Each indicator, shown at the right, is a fraction of time, and the numerators are smaller than or equal to the denominator because the times corresponding to losses are taken from here [10]. As follows are presented the equations and description of them.

$$\text{Availability} = \text{Total time scheduled (TTS)} / \text{Total time available (TTA)} \quad (1)$$

$$\text{Performance} = \text{Total time used (TTU)} / \text{Total time scheduled (TTS)} \quad (2)$$

$$\text{Quality} = \text{Total time of added value (TTAV)} / \text{Total time used (TTU)} \quad (3)$$

$$\text{ORE} = \text{Availability} \times \text{Performance} \times \text{Quality} \quad (4)$$

The explanation about the variables of the ORE is presented by [10] such as availability, performance and quality. The availability is calculated according to the total time scheduled (TTS) in relation to the total time available (TTA), this being the time when there is staff, equipment and materials available defined by senior management. Between the TTA and the TTS there may be wastes, such as equipment failure, setups and idleness due to the non-scheduling of surgeries. After calculating availability, the performance fee must be calculated, being obtained by the fraction of the total time used (TTU) by the total time scheduled (TTS). In this perspective, three other losses can occur as small shutdowns, variation in the time of surgery and cancellations of patients. Thus, after calculating the performance, it is proposed to calculate the quality, as a result of dividing the total time of added value (TTAV) by the total time used (TTU), and surgical reinterventions due to previous error may appear as a loss. Thus, at the end of calculating Availability, Performance and Quality, the ORE result can be obtained by multiplying these three intermediate indicators.

In short, the indicator ORE proposed [10] is a combination of the performance measures related to the timing of ORs with an integrated analysis of efficiency, effectiveness and signaling the losses [10] Also, the authors point out that the benefits of applying this indicator of efficiency for surgical center are: prioritization in safety and value for the patient; focus on the productivity of ORs, pointing out the times of operations and waste, and consider the losses of a surgical center, providing a systematic concept of efficiency for hospital managers.

To exemplify the application of this indicator its important to present two applications of that. The first one it is a case [20] of pilot application of the ORE to measure the efficiency of a surgical center of a hospital located in the center-west of Brazil. This application was based on the first version [21] of the ORE proposal performed by [10]. In this case, the availability losses were stratified only based on the waiting time to start the first surgery, which from that point on was identified that this waiting time was related to the setup time, waiting for professionals and incorrect scheduling. The availability index obtained was 78.81%. Regarding performance, a 65.2% index was obtained, and the losses found were related to idle times related to cancellations and small stoppages related to problems in equipment and material supply, besides the variation in planned time. Finally, the quality indicator was also defined as 100%. Thus, the average ORE resulting from this study was 51.39%.

Besides proposing the indicator, the research [10] demonstrates the application in a surgical center of a large hospital located in southern Brazil. The application of the ORE in this case was based on data from 10 months of the afore mentioned surgical center considering 7 Operating Rooms and with an average of 600 surgeries performed per month. The first important data is that the average efficiency obtained in the

period of 57.3%, going from 51% (December) to 63% (May), and having one each to 53% in July. In this case it was presented that the losses related to availability were related to the setup time for cleaning and preparation of ORs and not scheduling surgery, obtaining the index of 72.6%. The losses due to performance were related to the cancellations of surgeries and the variability of surgical time, resulting in a performance index of 78.9%. Moreover, it is worth mentioning that this application did not consider the losses by quality due to the absence of consistent data on surgical reiterations or other technical data, so the quality index was considered as 100%. Thus, the next section is described the methodology used to conduct this work.

3 Methodology

This is a case study carried out in a large general hospital based in Minas Gerais, Brazil. Such an organization has more than 100 years of history and performs highly complex procedures in its region, having applied a lean project over the past three years.

The project related to this article started in early 2019, with exploration and systematization of the ORE indicator, since it was not the hospital's reality to measure the data that make up this indicator, in addition to only using the Occupancy Rate as the main measurement. An internal team was selected by senior management in conjunction with external specialists in order to explore the efficiency of the surgical flow using the ORE indicator.

The ORE indicator was applied in the General Surgical Center unit, which contains 7 Operating Rooms. Their availability covers the period from 07:00 to 19:00. The schedule of surgeries covers the period from 07:30 to 19:00, except for availability for emergencies. The scheduling of surgeries is performed by the surgeon through a web scheduling system. The study and the actions worked focused on schedules from Monday to Friday, disregarding the operation of the surgical center on Saturdays, Sundays and holidays.

4 Application, analysis and discussion

The indicator was measured according to the metrics existing in the theory and the data taken from the hospital's information system and worked on by the hospital's internal team. The monthly ORE values for the year 2019 are represented in Figure 1. The average efficiency for the year 2019 was 60% and the study unit performed, on average, 864 surgeries / month. The quarterly average is also shown in the graphical analysis and indicates growth during the project cycles.

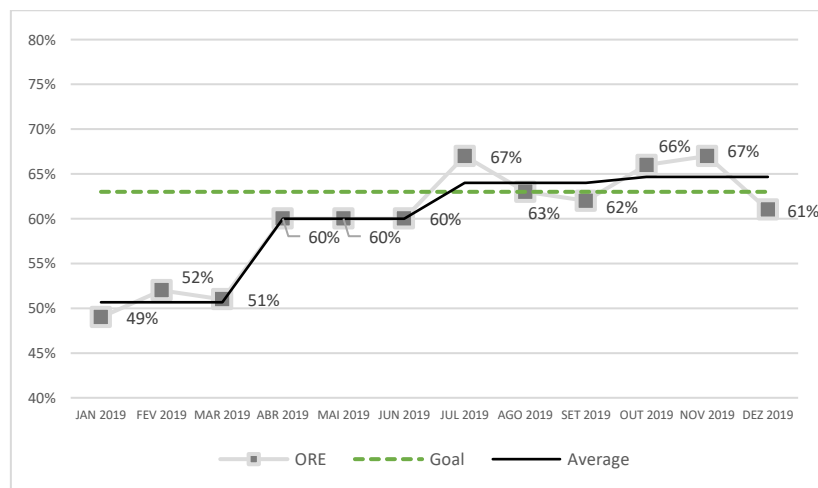


Fig. 1. Operating Room Effectiveness - General Indicator 2019.

The detailed indicator and its recommended losses can be seen in Figure 2. It can be seen that, on average, one month at the Surgical Center of this hospital, results in a TTA of 1,729 hours; a TTS of 1,355 hours, with 156 hours being lost in non-scheduling and 218 hours in setup; a TTU of 1,045 hours being lost 310 hours in surgery cancellations; and a TTAV of 1,045 hours, because the management decided to start with the previous losses, considering that there is already a quality project together with international certifications focused on patient safety. Thus, the average Availability in 2019 was 78.4%, Performance 77.1% and Quality 100%, resulting in an average ORE of 60.4%.

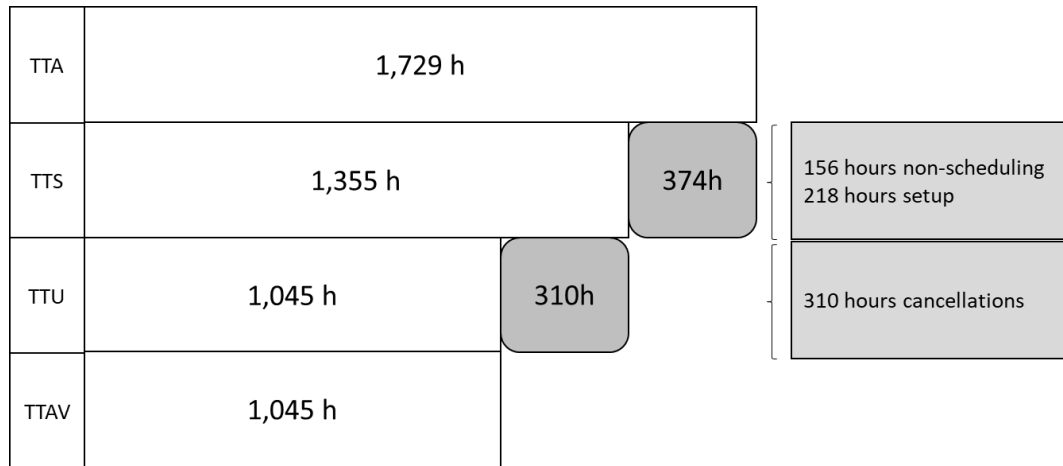


Fig. 2. Operating Room Effectiveness - Detailed Indicator and Losses 2019.

It is visible that during the evolution of the project the average ORE increased according to the effort in countermeasures carried out by the internal team. These measures focus on scheduling, setup, cancellations, physical organization and material management.

Applications can be analysed in general, considering the indicator's calculation method, its results and the main suggestions for improvement found in previous studies [20] and [10] comparing with this current study according to Table 1.

Table 1. Comparison between ORE studies.

	[20]	[10]	This Study
Availability	78.8%	72.6%	78.4%
Performance	65.2%	78.9%	77.1%
Quality	100.0%	100.0%	100.0%
ORE	51.4%	57.3%	60.4%
Key Improvements	<ul style="list-style-type: none"> • Cancellations • Waiting time 	<ul style="list-style-type: none"> • Cancellations • Scheduling • Setup 	<ul style="list-style-type: none"> • Cancellations • Materials Management • Physical organization • Scheduling • Setup • Waiting time

The studies complement each other and indicate that surgical centers of this size in Brazil can be between 50% and 60% of their efficiency according to the ORE indicator. And that the effective improvements must be concentrated in relation to the losses pointed out by the indicator. This study, by graph 1, shows the evolution of efficiency for three different periods, which can be presented as an evolution between the two previous studies [20] and [10], considering that more implementations with a focus on losses will generate an increase of efficiency in Operating Rooms.

5 Final considerations

The ORE indicator can serve as a great ally of managers and researchers working in the surgery production system. This study focused on the application of such indicator for one year in the flow of elective and emergency surgeries and found as a result an Availability of 78.4%, Performance of 77.1%, and Quality of 100.0% resulting in an ORE indicator of 60.4% as the year average. The evolution of OR efficiency is evident as the hospital team implements improvements with a focus on mitigating losses such as non-scheduling, cancellations, setup, as well as important flow operations such as scheduling, physical organization, material management, etc. A comparison with previous studies and this one, in three different hospitals, shows that they are between 50% and 60% of their efficiency according to the ORE, however, new studies must be carried out to confirm this conclusion statistically. It is suggested the application of ORE in other hospitals of the same size in Brazil and in other countries considering the existing losses and the main actions to intervene in increasing efficiency, in addition to studies between the ORE and the end-to-end value flow of patients surgical.

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