ANALYSIS OF SURGICAL PROCESSES

Central Operating Theatre – Centro Hospitalar Lisboa Norte

Mariana J. Patrão, Inês Marques, Ana Paula Barbosa-Póvoa

Centre for Management Studies, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal, *mariana.fernandes.j.patrao@tecnico.ulisboa.pt, ines.marques.p@tecnico.ulisboa.pt, apovoa@tecnico.ulisboa.pt*

Abstract

In the Portuguese National Health System, hospitals are critical once they aim to guarantee patient's requirements. Hospital's Operating Theatres are of most importance to hospitals and influence their outcomes. The large and time-consuming waiting list lead to the concern of continuously improve the service provided by improving the efficiency within the processes. Central Operating Theatre (COT) of Centro Hospitalar Lisboa Norte (CHLN) is the case understudy. The perioperative process of COT is mapped to identify the activities and resources within the process. This allows the detection of the flaw points existent in the process and the proposal of solutions. The development of intraoperative indicators is performed to help the organization to evaluate the intraoperative process. In addition, the development of a tool for Operating Room (OR) scheduling and materials' planning is performed.

Keywords: Central Operating Theatre, Operating Room, Perioperative Process, Inefficiency, Lean, Intraoperative indicators.

1. Introduction

Healthcare is a service industry where the requirements of patients (consumers) are critical to its development and should be aligned with the organization's objectives [1].

In Portugal, the National Health Service (*Sistema Nacional de Saúde*, SNS) aims to ensure the population's right to high quality healthcare treatment. Its main objective is to protect the individual and collective health and to do so, it is composed by integrated health care – promotion and vigilance of health, patient's disease prevention, diagnosis and treatment, and medical and social rehabilitation. The strategic path of the SNS is determined by the National Healthcare Plan (Plano Nacional de Saúde) which aims to maximize the gains in population's health by aligning and integrating sustainable efforts in all society's sectors and the focus is on access, quality, sustainable policies and citizenry. Considering this, the most recent National Healthcare Plan (until 2020) builds upon the previous ones and aims to maximize the results and to be aligned with the principles and strategic orientations of the World Health Organization [2].

In this context, Hospitals as critical organizations in the health system require organization of processes that guarantee a sustainable performance. A sustainable performance is not only a high financial capacity, but also an efficient use of available resources while meeting the patient's needs. Towards this, critical services within the hospital should be highly organized as is the case of OTs. The surgical interventions performed, in the OTs, are the major source of admissions into a hospital. This and the large and steadily

increasing surgical demand [3] [4], leads to a service with large expenses but also a source of revenues, while having a very important role in the health being of patients and in the performance of many other units of the hospital. For instance, recovery rooms are downstream services and provide a monitored rehabilitation of the patient after surgery. Therefore, OTs and the respective recovery rooms are critical assets to hospitals[5]. Moreover, the improvement of the processes in the operating theatres is critical to fulfill the requirements of *Sistema Integrado de Gestão de Inscritos para Cirurgia* (SIGIC) and reduce the waiting times of the patients, without increasing the available of resources and consequently the costs [6].

Thereby, COT is the case understudy and its inefficiency is a major concern to the stakeholders of Hospital Santa Maria (HSM) – CHLN. The objectives of this work are: 1) to understand the functioning of the organization's culture and processes, 2) to map the current perioperative process, and 3) to identify the existing flaw points which may lead to inefficiency.

2. Literature Review

Efficiency is a concern of all industries and healthcare, as a service industry, is not an exception. The identification of inefficiencies – lack of efficiency – is crucial and lead to an urge for improvement. In addition, the monitoring of the process is required to evaluate the obtained results. This can only be achieved by engaging the stakeholders in the improvement process.

2.1. Inefficiencies Causes and Solutions

Delays are the major inefficiency identified in healthcare systems. Delays may have origin in patients or the organization. Considering the patients, the main causes are the delayed for admission on surgery's day [7] [8] and the not attendance to consultations [9]. Moreover, the lack or time-consuming exams or labs results [7] [10] [11] – in preoperative - ignite surgical delays as for the 1st case starts and other cases during the day – in intraoperative. A surgery is conditioned by the patient to be the clearly informed or transferred to OR, the missing or redundant documentation for transferences [12] [10] [13] [14] or consents [8] [13] are a source of case's delays or cancellations. Moreover, the prolonged length of stay of patients is also a reason for delays which are caused by discharge's delays. This reflects on resources' occupation required for other admissions [15].

Considering the organization's causes – the hospital -, resources are the major contributor to lags in healthcare and have a relation with inefficiencies in processes. Misallocation or lack of beds [7] [15] [16] and inadequate equipment in procedure [17] [18] are considered origins of delay since both cause a stop in the system and consequently losses of value. In addition to equipment, the instruments are also linked to inefficiency in the process by lack of checklists for material preparation which bases on circulating nurse's knowledge [19] and may lead to inadequate surgical sets [17] [20]. Moreover, the lack of preparation and standard supplies [12] has also to be accounted as well as the disorganized storage of equipment and instruments [21] [22] which lead to time wastes and frequent OR door openings.

The existence of human resources is crucial in perioperative process. The unexpected absence of personnel [7] or lags directly related with nurses and doctors [10] compromises the functioning of the units and in some cases steer to their temporary closure [23] [24]. Doctors accumulate several functions that affect the arrival at the OR on time, such as morning rounds [13], evaluation of patients and requesting exams [11]. Likewise, nurses have overlapping activities [15] [25] [16] which compromise the respective functions.

By identifying the inefficiencies, the solution development can be performed. Standardization is the most used solution not only used in instruments and materials [19] [17] [7] but also, in activities performed by the professionals [13] [26], resulting in time

gains by decreasing wasted time and delays in the perioperative process.

2.2. Methods and Techniques

With inefficiencies and solutions identified from literature, it is important to access the methods used to develop the author's work. Different methods are used but the main are Lean Methodologies and Graphical Methods – mainly process map. In addition, Business Process Redesign can be used in healthcare projects to improve the systems' efficiency.

Graphical methods are used in both strategic and operational processes. Process map (PM) is a graphical tool to map the processes from beginning to end which exemplifies its functioning. Moreover, it supports stakeholders' engagement. As examples of PM, there is the works of Bouamrane [9], Copenhaver *et al.* [19], Krvavac *et al.* [8] and Aaronson *et al.* [12]. In all cases, the process is mapped, and the inefficiencies and waste are identified.

To study the material and product flows, Spaghetti Diagrams are used as a way of tracking the path of the materials or products and identify circuits leading to the development of flow improvement [27]. As an example of its use in healthcare is the study of circulate nurses' circuits to verify the impact of OR layout in circuits, as addresses by Bayramzadeh *et al.* [22].

Both graphical methods – PM and Spaghetti Diagrams – can be used as a single tool or associated to other methodologies, such as lean methodology. Lean methodology was first used in manufacturing by Toyota but has been applied also on services industry as it is the case of healthcare. Lean is used to improve the process by reducing the waste and betting on value-added activities to propel systems' efficiency. To healthcare, it is important to focus on valuable activities for the patient and reduce the waiting times and errors [8] [12] [19]. Lean is composed by several tools that can be used such as 5S, Kanban and most recently the association with 6 sigma – Lean 6 Sigma [11].In addition to this methodologies, it is the Business Process Redesign which is also used for efficiency improvement by involve the combination of business process, organization structure and information technology (IT) change [28].

2.3. OR indicators

Considering inefficiencies, solutions and techniques, the assessment of indicators evaluate processes before and after improvements implementation is required. Several authors use indicators without using this terminology to address them. Despite this, the Portuguese system has already some indicators used in the report of *Avaliação da Situação Nacional dos Blocos Operatórios* [4]. Moreover, it is verified a lack of standardized indicators that reflects on the choices of the different authors to monitor processes. Therefore, the standardization of the indicators is required although until then, the stakeholders must be involved in indicator's choosing since monitoring requires the most knowledge about the process.

2.4. Engagement of Stakeholders

To enhance the results obtained, the engagement of stakeholders is important since it is a contribution of different settings, understanding levels and goals. In addition, stakeholder's knowledge provides valuable insights of the organizations about problem's characteristics, participation into solution's identification and the model's construction, acceptance and results [29] [30] [31]. This engagement can be performed through different channels: interviews, surveys and meetings.

3. Case Study

The CHLN is a public hospital center and is a major reference to the National Health Service which provide direct health services to 375k inhabitants. Since 2007, CHLN is composed by two main hospital facilities: HSM and Hospital Pulido Valente. The COT of HSM – CHLN - is the case understudy.

In COT, four specialties perform elective surgeries – orthopedics, vascular, general and urology. In addition, there is the emergency surgery which considers all hospital's specialties. Based on this, COT's system can be described based on different

parameters, namely the surgical waiting list, facilities, process, surgery scheduling.

3.1. Surgical waiting list

All specialties have several types of patients, who are evaluated to access the pathology's urge for surgery and classified by using a priority system – from high priority to normal. This classification defines the Maximum Guarantee Response Time (MGRT) [32] to each priority level which may be compared with the actual waiting time of COT's patients [33]. It is possible to access that every specialty is complying the stablished MGRT resorting on COT's teams and surgical vouchers that allows the patient to receive treatment in other institution [34] [35].

Despite the compliance of the surgical waiting list to the MGRT, there is a large number of patients waiting for surgery in the different patient's classification, as the example of Table 1 [33].

Table 1: Number of patients in the waiting list who are evaluated as normal - non oncological disease [33].

Patient Classification	General Surgery	Vascular Surgery	Orthopedics Surgery	Urology Surgery
Normal – non-oncological disease	851	940	1037	493

3.2. Facilities

COT is in the 5th floor of HSM and it is composed by 5 OTs – 4 OTs in the 5th floor and another one in other location which is not considered to this work. Each OT is composed by 2 ORs, 2 disinfection rooms, a decontamination room, a material's storage room and a working room.

The allocation of the ORs to the specialties is performed as block scheduling – each room is allocated permanently to each specialty – and its allocation is performed by COT's direction (Table 2).

In addition to this OTs, there is a Post Anesthetic Care Unit (PACU) which works 24h a day and it aims to receive the patients after surgery for a 2/3h period.

Table 2: Distribution of the ORs by the specialties.

	OR A	OR B
OT 1	Orthopedy	Orthopedy
OT 2	General Surgery	General Surgery
OT 3	Vascular Surgery	Urology
OT 4	Emergency	Emergency

3.3. Process

COT has the perioperative process which considers the patient pathway and it is composed by 3 subprocesses – preoperative, intraoperative and postoperative - which complies all the activities from the identification of surgical requirement on the external consultation to the patient's discharge after surgery.

The preoperative process includes all activities from the external consultation to the patient's transference to the OT on the surgery's day, e.g. internment. When the patient arrives at the OT, the intraoperative process starts until the patient is transported from OR to the postoperative unit. The surgery's recovery is the postoperative process which includes patient's arrival to the postoperative unit until discharge.

3.4. Surgery Scheduling

The scheduling of activities has an important impact on COT's functioning. Each specialty is responsible for the cases' scheduling and respective presentation to COT's Director in the previous week. The surgical schedule considers the surgical hours from 8 a.m. to 8 p.m. from Monday to Friday for OT1 to OT3 with exception of emergency ORs which functions 24h a day, including weekends. Moreover, COT performs afterhours surgeries from the incentive system for the recovery of waiting lists for surgery [36] to overcome the high waiting lists.

In addition, a monthly scheduling is performed for personnel which may sustain changes due to unexpected constrains – e.g. absences and strikes. Considering elective surgeries, nurses may be assigned to 8 a.m. to 3 p.m. or 15 p.m. to 10 p.m. shift. The nurses from emergency ORs and PACU can be assigned 8 a.m. to 3 p.m.; 15 p.m. to 10:30 p.m. or 10:30 p.m. to 8 a.m. shift.

4. Methodology

An inefficiency problem of COT is identified, to solve it, a 4-step methodology is applied (Figure 1).

The 1st step – understanding – comprehends the understanding of COT to identify the problem and goals. In addition, the engagement of the stakeholders is performed.

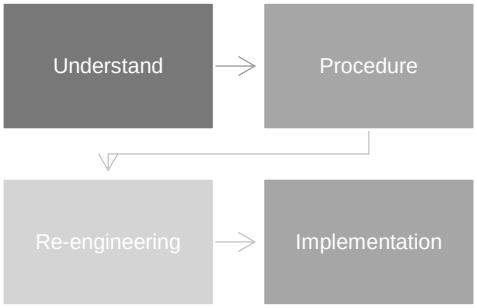

Figure 1: Methodology steps.

Subsequently, the procedure step takes place in which the perioperative process is mapped, and the flaw points are identified. With the identification of the flaw points, the re-engineering step begins by proposing solutions. One of these solutions is chosen – surgical duration and material planning. The Spaghetti Diagram is applied to evaluate the OR circuits and flaw point confirmation. Then, the development of a user-friendly tool for OR Scheduling and materials' planning is developed in Microsoft Excel.

The last step is the implementation of the solution into the real-life system and its evaluation.

5. Results presentation and Discussion

This section aims to present and discuss the obtained results considering the objectives defined. The 1st and 2nd objectives are directly related once process mapping requires the understanding of the organization's culture and processes. With this large understanding. With the process map, the identification of the flaw points can be performed, and solutions proposed - 3rd goal.

5.1. Process Mapping

COT's perioperative process is divided in 3 subprocesses – preoperative, intraoperative and postoperative. Each process has a sequence of activities describing the patient's pathway from external consultation to discharge. A macro and micro scale of the process map of each subprocess is performed and described separately.

5.1.1. Preoperative process

Preoperative process begins in external consultation – surgical requirement - until the patient's transport to OT.

The patient is referred from another health center to the CHLN and (s)he is evaluated on the external consultation by the surgeon to verify surgical requirement which generates a positive surgical decision if it is verified. Consequently, a surgical proposal is placed in the system and the patient enters the surgical waiting list.

To confirm the diagnosis, the patient performs a series of complementary exams, namely blood analysis, electrocardiogram (ECG) and thorax tele radiography (chest x-ray). With exams' completion, the patient is informed of the surgical procedure and proceed to the anesthesia consultation in which the anesthesiologist evaluates the patient and possible complications from anesthesia induction. Nowadays, the anesthesia consultation is only performed to the high-risk patients. Subsequently, the patient waits for the internment which occurs on surgery's previous day or on surgery's day if there are no available beds.
During the internment, the patient is observed by the anesthesiologist to confirm the data of anesthesia consultation or to collect data when there is no anesthesia consultation. Ultimately, the patient is transferred to the OT and the intraoperative process starts.

5.1.2. Intraoperative process

Intraoperative process starts with patient's arrival to the OT and it is completed with the transport to the post operatory unit.

The patient arrives at the OT and (s)he is prepared to enter the OR (e.g. moved to the marquise and removal of the internment clothes). When prepared, the patient enters the OR and (s)he is prepared for anesthesia induction. When anesthetized, the patient is positioned for the surgery and, in parallel, the material is prepared, and the surgeons are scrubbing in.

With all conditions united, the surgery is performed, and which duration is dependent on surgeons' experience and the pathology's extension. Before surgery's end, the material used is confirmed by the medical team and the patient is closed and waken up by the anesthesiologist and anesthesia nurse. When the patient is awake and responsive, (s)he is transferred to the interchange area and prepared for transport to post operatory unit. The transportation completes the activities from intraoperative process.

5.1.3. Postoperative process

The postoperative process begins with the patient arrival at the post operatory unit which depends on the patient's health state and level of monitorization required. If the patient requires a high monitorization and the health state is considered critical, (s)he is transferred to the intensive care unit. When there is a medium monitoring necessity, the patient is directed to the intermediate care unit. Otherwise the patient goes to PACU.

In PACU, the patient, anesthesiologist and the anesthesia nurse are received by PACU's team and informed about the patient state. After patient's monitoring in PACU and patient has conditions to be transferred, (s)he is directed to a suitable unit – e.g. from PACU, (s)he is transferred to the nursery. In the nursery, the patient is evaluated and monitored. Then, the discharge is provided by the surgeon and the patient goes home.

5.2. Flaw points and proposed solutions

With the process map of the perioperative process, it is possible to identify the flaw points in each subprocess – preoperative, intraoperative and postoperative. The identification is performed by observations on sight and professionals' knowledge of the different subprocesses.

5.2.1. Preoperative Process

Preoperative process is vast and consequently, there are several flaw points identified. The lack of surgical proposal is an identified flaw point with origin in the lack of submission by the surgeon or the expired validity due to patient's health state changes. Considering the anesthesia consultation, there is a lack of anesthesiologists and planning to perform this process activity since there is a lack of professionals and, in addition, there is absences and lags. To overcome this, the introduction of a digital anesthesia consultation would allow the patient's data collection before internment. On surgery's day, the patient is seen by the anesthesiologist and there is an identification of the inexistence of patients or its validity expiration that can be overtaken by the confirmation of the existence of the exams with a phone call on the previous days.

Moreover, the maladjustment of capacity to demand, demand's bad planning, lack of an integrated planning of process and the lack of clinical structure may reflect on the lack of beds in the internment. As a solution proposal, it is the integrated management of patients. To enter the intraoperative process, the patient transportation is required to the OT resulting on problems. A cause to this may be the lack of professionals overcome by the flexible scheduling of professionals; unknown location of patient; delay on patient's preparation; and lack of communication.

5.2.2. Intraoperative Process

In similarity to the preoperative process, intraoperative process presents several flaw points.

It is possible to identify 3 main flaw points: transportation, anesthesia delays and surgical delays. These flaw points have a human origin or a planning origin. It is visible the existence of the same origin to different

flaw points, such as the anesthesia delay and surgical delays, which have origin in the professionals and OR materials. Moreover, the surgical planning is also appointed as a cause for surgical delays since there is no borders defined to the surgical duration. This means that the occupation of the OR does not always consider the anesthesia and cleaning duration, which lead to errors and delays to the next surgeries.

The solution proposed is developed with the assistance of the tool in Microsoft Excel which is addressed in the next section.

5.2.3. Postoperative Process

Postoperative process is the less vast subprocess within the perioperative process and consequently, the one which presents the smaller number of flaw points.

Once again, the transportation problem is presented as a flaw point. In addition, the discharge delays influence the downstream activities since the patient's bed is required for new internments. As causes for discharge delays there is the lack of availability of the surgeon and the post clinical structure. The first cause may be overcome by the introduction of more discharge periods and the 2nd by the integrative management of patient.

5.3. Developed Solutions

Based on the identified flaw points, 2 solutions are developed to provide a tool for efficiency improvement in the perioperative process – intraoperative indicators and tool for OR scheduling and materials' planning.

5.3.1. Intraoperative Indicators

The inexistence of defined indicators in COT's system and more specific to the intraoperative process is of most concern. The intraoperative process requires the most closely monitoring since it concentrates 2 critical activities – surgery and anesthesia. Based on this, several indicators are defined to be applied (Table 3). These indicators are divided in 6 classes based on the report of *Avaliação da Situação Nacional dos Blocos Operatórios* [4]. By implementing the proposed indicators (Table 3), it is expected a close monitoring and evaluation of the current state and the improvements provided by the tool implementation.

Table 3: Defined intraoperative indicators.

Class	Indicators
Quality	• % of daily compliance to the scheduled surgical plan; • Case duration accuracy; • % of first cases on-time; • % of patients with signed surgical consent before entering the OR.
Complexity	• Number of different resources used; • Availability of instruments;
Occupation	• OR occupancy level; • % of resources utilization.
Cancellations	• % of cancelled surgeries; • % of delayed procedures due to patient's delays; • % of delayed procedures due to medical team delays;
Time	• % of idle time; • % of overtime; • Average patient time in the OT; • Average delay for cases not on-time; • Average OR preparation time.
Satisfaction	• Patient-reported outcomes; • Medical team complaints.

5.3.2. Tool for OR scheduling and material planning

Surgical delays is one of the identified flaw points in the intraoperative process. Knowing the criticality of the surgery and anesthesia, its overcome is of most concern. Considering the identified origins, there is the bad planning provided by not considering the anesthesia and cleaning times in the surgical plan; and the inexistence of materials' planning or defined supplies within the OR.

To confirm these flaw points and its origins, Spaghetti Diagrams are performed to evaluate the OR circuits. These Spaghetti Diagrams consider only the Circulant Nurse

(Figure 2) and the Anesthesiologist and Anesthesia Nurse (Figure 3) who are the professionals in the OR that perform more movements.

The Spaghetti Diagram allows to conclude the large number of movements within the OR by the health professionals. This movements need to be reduced since they demonstrate the waste in time and value of the activities performed within the OR – e.g. to get supplies not planned and not present in the OR. Therefore, it is developed a tool which allows OR scheduling according to each surgery type and specialty, and to define the quantities of each supply to have in the OR to fulfill the daily demand based on the OR schedule.

Figure 2: Spaghetti Diagram of Circulant Nurse's circuits, in OT4.

Figure 3: Spaghetti Diagram of Anesthesiologist (orange) and Anesthetist Nurse's (blue) circuit, in OT4.

Based on this, the objective of this tool development must be defined before its starting phase – tool user-friendly which provides support for the specialties in surgery's scheduling and material planning, which reflects directly on the efficiency of the system. The tool is developed in Microsoft Excel, so the professionals can use it without requiring an extra program in their computer and since this program can be considered easy to use by all stakeholders – administratives and doctors - since they already use it for diverse aspects – e.g. for the OR block scheduling. In addition, the excel sheets are in Portuguese so the user can have a direct association to its language.

Considering the defined objectives, data from OT occupation is collected from CPCHS Software and with this, eliminate the requirement of observations on sight. The used data is from the period between March and April of 2018 and considers specialty, surgery and times – arrival at OR, entrance in OR, beginning of anesthesia, beginning of surgery, end of surgery, end of anesthesia, exit of OR, exit of OT.

The data is treated and the average occupation of the OR by each patient is calculated considering the surgical duration, the anesthesia duration and the cleaning duration, as may be accessed in Table 4.

Table 4: Sample of the treated data.

Specialty	**Surgery**	**Average Duration (h)**
Cirurgia Geral - U. Internamento	ABLACAO DO ENDOMETRIO	03:58:00
Urologia - U. Internamento	ADRENALECTOMIA BILATERAL	02:45:00

Considering this data (Table 4), the tool is developed. In the first column, the user chose the surgical specialty. With the specialty chosen, the user can chose the surgery (s)he intends to perform (Figure 4) – 2nd column – and the duration regarding the OR occupation automatically appears in the tool (Figure 5).

Figure 4: Selection of surgery to perform.

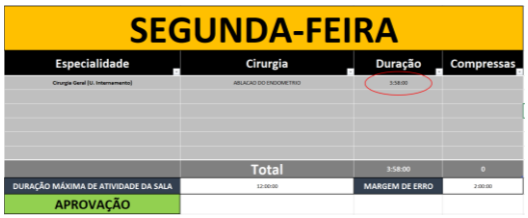

Figure 5: Duration regarding the OR occupation.

Moreover, when there is available data, the number of materials required can appear in the 3rd column as it is illustrated in the compresses' column.

To help the user to control the total scheduled duration and compare it with the maximum OR activity duration (12h), a cell regarding the total duration is used and a semaphore color alert is performed in the "*Aprovação*" cell. This cell returns a green color if the total scheduled duration is under 10h; yellow if the scheduled duration is between 10h and 12h; and a red color if the scheduled duration is over 12h.

It is expected with this tool to decrease the number of movements of the professionals observed in the Spaghetti Diagram and consequently, improve the system's efficiency.

As future work, the surgeon and anesthesiologist who perform the surgery and anesthesia must be considered for calculating the average duration since it is influenced by its responsible.

6. Conclusions and Future Work

The perioperative process of COT is a complex system which involves many activities and resources. Its understanding is of most importance to the right characterization and description of activities. In addition, it is crucial the engagement of the stakeholders in the process map and the identification of flaw points. Solutions for the flaw points are proposed and 2 solutions are developed: intraoperative indicators and a tool for OR scheduling and materials' planning is developed comprehending the surgery duration, the anesthesia duration and the cleaning duration to improve the scheduling accuracy.

Several aspects can be further developed in the future. The Excel tool might include the option to consider the anesthesiologist and the surgeon that performs the surgery to compute the surgery duration and the type of surgery to compute the cleaning time. In addition, it is recommended the qualitative evaluation of the current state of the process and the comparison with the state achieved by the implementation of the proposed and developed solutions. With this evaluation, a new assessment of the flaw points should be performed, and the solutions proposed adapted, and further and new solutions proposed. By continuously monitoring and controlling the system, as well as implementing the solutions is expected to improve COT's efficiency. Moreover, as future work, it is the implementation of the dissertation's methodology to other specialties to access their state and consequently, if verified the same flaw points, the implementation of the OR Scheduling and material's planning tool in their services.

References

[1] R. Grover, "Healthcare marketing: The paradigm shift," *Curr. Med. Res. Pract.*, vol. 6, no. 3, pp. 138–139, 2016.

[2] Ministério da Saúde. Direcção-Geral da Saúde, "Plano Nacional de Saúde: revisão e extensão a 2020," 2015.

[3] Ministério da Saúde, "Relatório Anual: Acesso a Cuidados de Saúde nos Estabelecimentos do SNS e Entidades Convencionadas," 2016.

[4] V. R. Jorge Penedo, Gil Gonçalves, Lucindo Ormonde, Maria Barros, Mercedes Carvalho, Pedro Gomes, Rui Vasconcelos e Sá, "Avaliação da Situação Nacional dos Blocos Operatórios," 2015.

[5] F. Guerriero and R. Guido, "Operational research in the management of the operating theatre: A survey," *Health Care Manag. Sci.*, vol. 14, no. 1, pp. 89–114, 2011.

[6] A. Agnetis, A. Coppi, M. Corsini, G. Dellino, C. Meloni, and M. Pranzo, "Long term evaluation of operating theater planning policies," *Oper. Res. Heal. Care*, vol. 1, no. 4, pp. 95–104, 2012.

[7] M. E. Kuhl, "A Simulation Study of patient flow for day of surgery admission," *Proc. 2012 Winter Simul. Conf.*, no. 2009, pp. 1219–1229, 2012.

[8] A. Krvavac *et al.*, "Evaluating and Improving the Efficiency of Patient Flow in the Bronchoscopy Suite in a Tertiary Care Center: A QI Project!," *Qual. Manag. Health Care*, vol. 27, no. 1, pp. 33–38, 2018.

[9] M. Bouamrane, M. McGee-Lennon, S. Brewster, and F. Mair, "Using Process-Mapping to Design Integrated Health Information Management Systems," *Proc. 24th IEEE Int. Symp. Comput. Med. Syst.*, pp.

1–6, 2011.
[10] J. Franklin and T. Franklin, “Improving Preoperative Throughput,” *J. Perianesthesia Nurs.*, vol. 32, no. 1, pp. 38–44, 2017.
[11] K. DeGirolamo *et al.*, “Process mapping as a tool for performance improvement in emergency general surgery,” *Can. J. Surg.*, vol. 61, no. 1, pp. 13–18, 2018.
[12] E. Aaronson, E. Mort, and S. Soghoian, “Mapping the process of emergency care at a teaching hospital in Ghana,” *Healthcare*, vol. 5, no. 4, pp. 214–220, 2017.
[13] C. J. Warner *et al.*, “Lean principles optimize on-time vascular surgery operating room starts and decrease resident work hours,” *J. Vasc. Surg.*, vol. 58, no. 5, pp. 1417–1422, 2013.
[14] A. Damle *et al.*, “Elimination of waste: creation of a successful Lean colonoscopy program at an academic medical center,” *Surg. Endosc. Other Interv. Tech.*, vol. 30, no. 7, pp. 3071–3076, 2016.
[15] S. Zhang, Q. Huang, J. Xie, B. Xu, G. Cao, and F. Pei, “Factors influencing postoperative length of stay in an enhanced recovery after surgery program for primary total knee arthroplasty,” *J. Orthop. Surg. Res.*, vol. 13, no. 1, pp. 1–7, 2018.
[16] J. Criddle and J. E. Holt, “Use of Simulation Software in Optimizing PACU Operations and Promoting Evidence-Based Practice Guidelines,” *J. Perianesthesia Nurs.*, pp. 1–6, 2017.
[17] J. R. Avansino, A. B. Goldin, R. Risley, J. H. T. Waldhausen, and R. S. Sawin, “Standardization of operative equipment reduces cost,” *J. Pediatr. Surg.*, vol. 48, no. 9, pp. 1843–1849, 2013.
[18] G. Palmer *et al.*, “Realizing improved patient care through humancentered operating room design: A human factors methodology for observing flow disruptions in the cardiothoracic operating room,” *Anesthesiology*, vol. 119, no. 5, pp. 1066–1077, 2013.
[19] M. S. Copenhaver *et al.*, “Improving operating room and surgical instrumentation efficiency, safety, and communication via the implementation of emergency laparoscopic cholecystectomy and appendectomy conversion case carts,” *Perioper. Care Oper. Room Manag.*, vol. 8, no. August, pp. 33–37, 2017.
[20] A. R. Dyas *et al.*, “Reducing cost and improving operating room efficiency: examination of surgical instrument processing,” *J. Surg. Res.*, vol. 229, pp. 15–19, 2018.
[21] A. Joseph, S. Bayramzadeh, Z. Zamani, and B. Rostenberg, “Safety, Performance, and Satisfaction Outcomes in the Operating Room: A Literature Review,” *HERD Heal. Environ. Res. Des. J.*, vol. 11, no. 2, p. 193758671770510, 2017.
[22] S. Bayramzadeh *et al.*, “The Impact of Operating Room Layout on Circulating Nurse’s Work Patterns and Flow Disruptions: A Behavioral Mapping Study,” *HERD Heal. Environ. Res. Des. J.*, p. 193758671775112, 2018.
[23] LUSA, “Greve dos enfermeiros com adesão entre os 83 % e os 96 %,” pp. 1–4, 2018.
[24] LUSA, “Greve dos enfermeiros adia mil cirurgias no São José , Santa Maria e São João,” pp. 1–4, 2018.
[25] D. Marsh, N. G. Patel, W. M. Rozen, M. Chowdhry, H. Sharma, and V. V Ramakrishnan, “Three routine free flaps per day in a single operating theatre: principles of a process mapping approach to improving surgical efficiency.,” *Gland Surg.*, vol. 5, no. 2, pp. 107–14, 2016.
[26] A. E. Pugel, V. V. Simianu, D. R. Flum, and E. Patchen Dellinger, “Use of the surgical safety checklist to improve communication and reduce complications,” *J. Infect. Public Health*, vol. 8, no. 3, pp. 219–225, 2015.
[27] M. Romanowski and K. Nadolny, “Methods of graphical analysis of production processes,” *J. Mech. Energy Eng.*, vol. 2, no. 1, pp. 33–42, 2018.
[28] D. B. Stoddard and S. L. Jarvenpaa, “Business process redesign: Tactics for managing radical change,” *J. Manag. Inf. Syst.*, vol. 12, no. 1, pp. 81–107, 1995.
[29] V. de Gooyert, E. Rouwette, H. van Kranenburg, and E. Freeman, “Reviewing the role of stakeholders in Operational Research: A stakeholder theory perspective,” *European Journal of Operational Research*, vol. 262, no. 2. Elsevier B.V., pp. 402–410, 2017.
[30] E. P. Tagge, A. S. Thirumoorthi, J. Lenart, C. Garberoglio, and K. W. Mitchell, “Improving operating room efficiency in academic children’s hospital using Lean Six Sigma methodology,” *J. Pediatr. Surg.*, vol. 52, no. 6, pp. 1040–1044, 2017.
[31] K. E. Hacker and A. B. Smith, “Engaging Stakeholders and Patient Partners,” *Surg. Oncol. Clin. N. Am.*, 2018.
[32] Diário da República, “Portaria n.º 153/2017,” 2017.
[33] Serviço Nacional de Saúde, “Tempos Médios de Espera do Serviço Nacional de Saúde,” 2017. [Online]. Available: http://tempos.min-saude.pt/#/instituicao/218.
[34] LUSA, “SNS 24 vai ajudar doentes a escolher hospital e marcar cirurgia,” *Público*, 2017.
[35] A. C. do S. de Saúde, “Perguntas Frequentes sobre a Gestão da Lista Cirúrgica Sistema Integrado de Gestão do Acesso (SIGA) Unidade de Gestão do Acesso (UGA),” pp. 1–22, 2017.
[36] A. Campos, “Médicos operam mais depressa quando recebem incentivos financeiros,” pp. 1–4, 2013.