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A framework to improve surgery roadmap efficiency based on design thinking, lean manufacturing techniques, and operations research applications

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Abstract

A surgery patient is a unique medical patient due to its requirements, not in the treatment itself but its prevention of post-operative complications affecting the user's close circle experience. Indeed, the patient journey is a crucial cross-functional business process because of the action and information flow between stakeholders and medical systems. Poor patient flow can reduce productivity, increase the risk of harming patients, and reduce the level of quality perceived by patients. Thus, hospitals can enhance the quality of the processes by understanding this roadmap.

Consequently, this work focuses on establishing a framework that details the medical patient roadmap considering three approaches: Design Thinking (DT), Lean Manufacturing Techniques, and Operations Research Applications (OR). This work implements the Lean manufacturing Techniques in healthcare (a.k.a., Lean Healthcare) to describe the roadmap's processes, bottlenecks, and mapping value. In parallel, the Design Thinking tools help to draw solutions through co-creation processes, including various stakeholders such as doctors, nurses, engineers, patients, and support staff. Finally, the Simulation tools help enhance the rapid prototyping regarding the roadmap's process modification.

This work implements the three approaches in a healthcare institution in Colombia to improve surgery roadmap efficiency and compiled them into a theoretical framework.

***Keywords**: Lean Healthcare, Practical Innovation, Framework, efficiency.*

Introduction

Ensuring a healthy life and promoting the well-being of all ages is essential for building prosperous societies (UN, 2015; United Nations, 2015). Thus, it is vital to consider the different advances that have been made in public policy issues to improve people's health and well-being. Unfortunately, there are still inequalities in access to health care. This inequality is why one of the objectives proposed in the 2030 Agenda for Sustainable Development focuses on meeting people's health and well-being needs (UN, 2015; United Nations, 2015). In particular, SDG 8 proposes "to achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all" ((Programa de las Naciones Unidas para el Desarrollo (PNUD), 2020). Similarly, this objective also raises the need to increase health financing and support for the workforce in developing countries, suggesting promoting the recruitment, upgrading, training, and retention of health personnel in developing countries.

Consequently, the UN's members have national, departmental, and local policies aligned with the 2030 Agenda for Sustainable Development. For instance, the Colombian government has the pact for equity, presented by the current government in the national development plan, establishing "Health for all: with quality and efficiency, sustainable for all." For the above, the main objectives are to achieve user satisfaction by providing more outstanding quality and opportunity in care, as well as providing human talent and health infrastructure to the regions of the country according to their needs" (Departamento Nacional de Planeación, 2019). At the state level, this work highlights the Santander case. The 2020-2023 development plan proposes the social and environmental balance as strategic. (Gobernación de Santander, 2020). This component has, among others, the objective of improving the population's health conditions and the adequacy of the supply of services to achieve the expected results in the health of individuals, families (and communities) to guarantee the right to health in the state.

The Santander case is remarkable due to the different healthcare institutions that meet the demand for health services in the department. This work highlights the particular case of the FOSCAL organization. This institution has emergency rooms, general, ophthalmological, outpatient surgery, intensive care units for adults and pediatrics, and hospitalization, among other specialized layouts. Indeed, the organization generates around 2,000 direct and 700 indirect jobs and has 350 health specialists, 410 hospital beds, 102 intensive care units, and

27 surgery rooms. (Clínica Foscal, 2021). Considering the complexity of the services it provides, the FOSCAL Medical Complex has defined social responsibility as a guiding principle within its guidelines, looking to contribute to the sustainable development of the health sector, the improvement of its working population, the reduction of impacts on the environment, the provision of safe and humanized services, and support for the most vulnerable population, as well as society in general (Clínica FOSCAL, 2021).

In this sense, this work proposes to develop a framework to improve surgery roadmap efficiency based on design thinking, lean manufacturing techniques, and operations research applications. This work uses the FOSCAL organization's capabilities to analyze the current state of its processes and propose improvement strategies that will positively impact the monitoring indicators. These indicators' improvement will relate to the quality of the service provided to the population. Nevertheless, this work delimits the attention processes to two main ones: General Surgery (GS) and Ophthalmological Surgery (OS) services. Both processes represent fundamental components of the health system, and good practices in these services positively impact the system's overall performance.

Indeed, surgery is an action-oriented medical discipline and is of the utmost importance for the timely resolution of different surgical pathologies that, depending on their severity, will require different types and times of intervention. Consequently, there is significant variability in the care route of the surgery rooms, so increasing the efficiency of the activities that comprise it represents a fundamental objective for the FOSCAL organization. This optimization implies a better quality of attention to the end-user, which generates well-being for the community. Likewise, the entity will be able to standardize, improve productivity, and organize the different processes so that the patients flow across the process the best possible. So, quality, satisfaction, and opportunity indicators reflect this enhancing approach. On the other hand, the institution benefits from its good image and organizational and care work, thus generating value for its stakeholders.

1.Aims and objectives

Considering the significant variability in the care route of the surgery rooms, increasing the efficiency of the activities that comprise patients' attention represents a fundamental objective for organizations in the health area and research centers, including universities. This work highlights joint work between academy and industry in the context of applied research in topics such as process improvement, innovation management, and digital transformation. Thus, this work requires heterogeneous professional profiles, including quality management, nurses, surgeons, engineers, and human resources professionals, to get a comprehensive strategy for fulfilling the third sustainable development goal. In summary, this project proposes a framework to improve surgery roadmap efficiency based on design thinking, lean manufacturing techniques, and operations research applications, working on an applied case in the FOSCAL organization.

2.Methodology

Continuous improvement practices in the health area make it possible to increase the efficiency of care systems. Costa & Godinho Filho (2016) indicate that most applied methodologies: 5S, Team Problem Solving, Spaghetti Diagram, Workload Balancing, Continuous Flow Analysis, Andon, Kaizen Event, Jidoka, Kanban, Product Flow Analysis, Poka-yoke, Process Redesign, Heijunka, Process Redesign physical work environment, and work standardization. The importance of improving efficiency in care routes in the health sector is such that it is a topic of research interest in the best academic and health institutions worldwide, such as Harvard Medical School (Maruthappu et al., 2016; Overdyk et al., 2016; Specht et al., 2020; Xu et al., 2019), Massachusetts General Hospital (Chen et al., 2009; Overdyk et al., 2016), Medical University of South Carolina (Catchpole et al., 2018; Jain et al., 2016), o Toronto University (Braddock et al., 2008). These researches are empirical, meaning each service provider unit or institution has characteristics in its processes and human capital that make them unique; therefore, it is necessary to develop custom upgrades processes.

Consequently, empirical and longitudinal studies must improve surgery roadmap efficiency. This work analyses a hypothetical sample representing end-users (patients) (Heumann et al., 2016; Walpole & Myers, 2012). This work uses mixed methods (Timans et al., 2019), such as: (i) the system description using lean manufacturing tools (Wang, 2010) and design thinking, (ii) the analysis of alternatives through a set of numerical simulation techniques and operations research (Association for Computing Machinery, 2020; Hillier & Lieberman, 2001), (iii) the software deployment using iterative methodologies (Boehm, 1986; Cockburn, 2004), the technology transfer assessment analyzing the perceived ease-of-use (Davis, 1989; Nguyen et al., 2020) and usability (Sauro & Lewis, 2016; Sharp et al., 2019). Next, there is a brief description of the methods implemented.

The main objective of Lean healthcare is to identify and eliminate operational waste, focusing on improving patient flow through the healthcare system (Akmal et al., 2020). Recently, in these organizations, the provision of health services has been approached from the patient's point of view and not from departments or functions. In search of more effective and efficient care, healthcare organizations are considering comprehensive improvement systems for their services' essential functions and processes.

Design thinking stood out as a research and applied innovation framework which gives priority to the users of a product or service, involving collaborative work and actions aimed at the rapid creation of prototypes from their ideas (Roberts et al., 2016), as a consequence of the rapid and accelerated changes in the market towards integrated products and services. Indeed, organizations must invest in innovation strategies, staff training, and close relationship with the client. Thus, Design thinking helps implement this strategy in the execution and analysis of the activities, favoring an iterative process.

Operational research aims to support decision-making in solving real problems through mathematical and computer models. In health systems, this approach has applications through different techniques, such as Discrete Event Simulation, linear programming, integer linear programming, Markov chains, queuing theory, and data envelopment analysis, among others. Using and applying these methods will help managers understand the system and its processes from a comprehensive perspective, favoring personnel management, cost control, and the study of productivity (Bagherian et al., 2020).

3.Results

This work defines an iterative framework with four stages based on the theoretical background and preliminary results. The stakeholders work together across the stages, including Decision-makers, Investors, Surgeons, Engineers, Nurses, Patients, Secretaries, Support staff, and Undergraduate students. Depending on the current stage, the interaction between stakeholders will change. Another critical point is the iterative structure of the framework due to two aspects. Firstly is the continuous improvement in the institution to apply optimization strategies frequently. Secondly, the life-cycle design supports this framework because it is necessary to implement rapid prototyping to generate and improve solutions quickly. Fig. 1 summarizes the framework wherein the activities in each stage could go forward or backward.

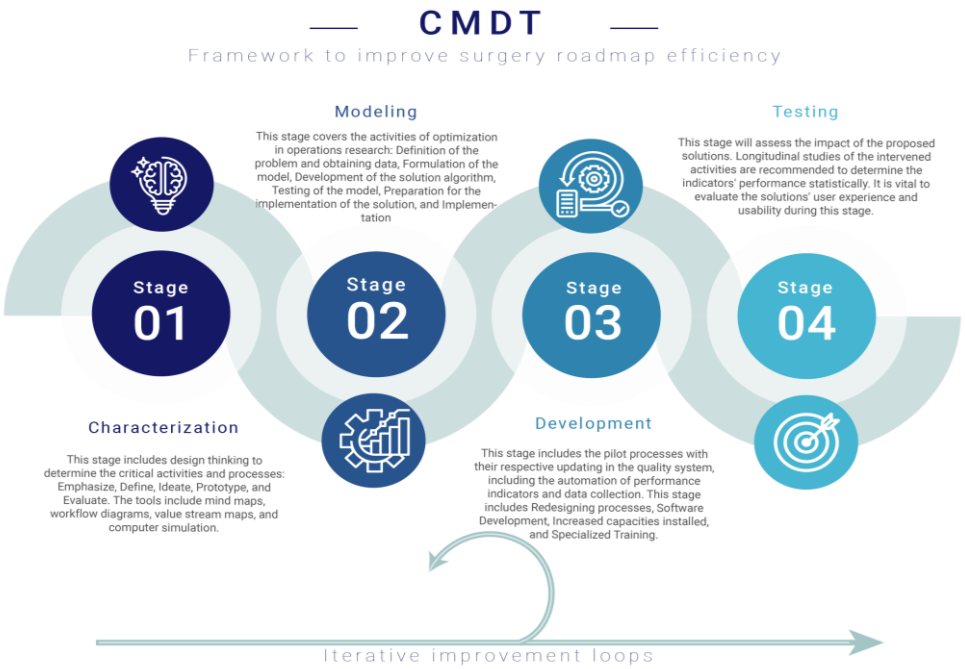

Fig. 1 Framework to improve surgery roadmap efficiency

Implementing mixed methods is crucial to knowledge generation regarding the surgery roadmap. For instance, available information about the beginning and end times of the patient in the surgery roadmap is rarely due to the system complexity, no matter the use of robust software such as SAP in this applied example. In the Colombian context, this complexity appears because even if the patient enters an institution-building, the software does not necessarily record the patient's admission. Other cases occur when the patient cannot enter the institution but is already waiting to start the route. Then, matching the recording data with semi-structured interviews allows the researcher to model the system using software like process simulation. That software such as Felxsim, Arena, Promodel, or high-level software such as Python, MatLab, and R, among others, allows estimating the capacity of the roadmap quickly and at low cost instead of generating a time analysis process by process. Nevertheless, this approach occurs when the stakeholders work together to describe the system using lean manufacturing tools.

On the other hand, stages Three and Furth focus on the solution implementation. Those solutions depend on decision-makers, and the current budget, including the Automation of performance indicators and data collection, Redesigning processes, Software Development, Increased capacities installed, and Specialized Training. Nevertheless, to guarantee continuous improvements, it is necessary to test the deployed solution, including process performances and the interaction between end-users (e.g., patients, support staff, decision-makers, and healthcare professionals) and machinery covering software, hardware, and data.

Discussions

From the two-stage process regarding literature review and empirical findings above, key results indicate the relevance of exploring mixed methods to enhance the co-creation process. (i) Several researchers investigated the application of lean manufacturing techniques in the health sector. (ii) Instead of spending resources on data gathering (money and time), combining semi-structured interviews and simulation tools allows the system description and the estimation of performance indicators. (iii) This study helps researchers to identify stakeholders, strategies, and tools to generate solutions related to improving surgery roadmap efficiency. (iv) It is necessary to evaluate the solutions' ease-of-use and usability because the system complexity demands the custom solutions for centered users. Nevertheless, it is necessary to implement this approach to validate the times and number of loops to generate a solution. The preliminary results in the FOSCAL institution led us to estimate the process baseline. Thus, in future works, we will implement the solution to compare the performance indicators and validate the framework.

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