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LEAN HEALTHCARE IMPLEMENTATION: EXPERIENCES AND LESSONS LEARNED FROM BRAZILIAN HOSPITALS

Implementação do lean healthcare: Experiências e lições aprendidas em hospitais brasileiros

Implementación del lean healthcare: Experiencias y lecciones aprendidas en hospitales brasileños

ABSTRACT

This study aimed to analyze the process of implementing lean healthcare in three Brazilian hospitals that have played a pioneering role in the implementation of this system. We adopted the case study approach and collected data through interviews, document analysis, and observation. The results showed that the processes of implementation of lean healthcare in the hospitals shared many similarities in terms of the flow of patients, materials, or information. Finally, it was possible to obtain some guidelines for the application of lean principles and techniques in order to facilitate the implementation of lean healthcare in hospital operations.

KEYWORDS | Lean production, lean healthcare, service operations, healthcare operations, case studies.

RESUMO

Este artigo tem como principal objetivo analisar como ocorreu o processo de implementação do lean healthcare em três hospitais brasileiros que exerceram um papel pioneiro na aplicação desse sistema. Foi utilizada a abordagem metodológica do estudo de caso, adotando como técnicas de coleta de dados entrevistas, análise documental e observação. Os resultados evidenciaram que os processos de implementação da produção enxuta nos três hospitais tiveram muitas semelhanças, seja nos fluxos de pacientes, materiais ou informações. Por meio da pesquisa, foi possível extrair diretrizes quanto à aplicação das técnicas e dos princípios enxutos de modo a fornecer suporte às operações hospitalares na implementação da produção enxuta.

PALAVRAS-CHAVE | *Produção enxuta, lean healthcare, operações de serviços, operações hospitalares, estudos de caso.*

RESUMEN

Este artículo tiene como principal objetivo analizar cómo se dio el proceso de implementación del lean healthcare en tres hospitales brasileños que desempeñaron un papel pionero en la aplicación de dicho sistema. Se utilizó el abordaje metodológico del estudio de caso, y se adoptaron como técnicas de recolección de datos entrevistas, análisis documental y observación. Los resultados evidenciaron que los procesos de implementación del lean healthcare en los tres hospitales han tenido muchas semejanzas, ya sea en los flujos de pacientes, material o información. Finalmente, mediante la investigación, fue posible extraer directrices respecto a la aplicación de las técnicas y de los principios lean a los efectos de proporcionar soporte a las operaciones hospitalarias en la implementación del lean healthcare

PALABRAS CLAVE | *Producción ajustada, lean healthcare, operaciones de servicios, operaciones hospitalarias, estudios de caso.*

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INTRODUCTION

Health services in Brazil have been expanded over the last few years. However, public investment in this sector is still insufficient (Brazilian Institute of Geography and Statistics [Instituto Brasileiro de Geografia and Estatística, IBGE], 2013), resulting in low quality services (Cunha & Corrêa, 2013). In Brazil, there are 2.3 beds per 1,000 inhabitants, which is below the recommended target by the Ministry of Health and a challenge to the provision of adequate assistance (IBGE, 2013). Health services in Brazil also present many management inefficiencies: out of the more than 6,000 Brazilian hospitals, only 259 were accredited by the National Accreditation Organization (Organização Nacional de Acreditação [ONA], 2017).

The low quality of health services and the need for more effective resource management led to the adaptation of certain methods and tools commonly used in manufacture to health services, with a highlight for lean production (LP) (Cunha & Corrêa, 2013; Haddad, Gregory, & Wickramasinghe, 2014; Suárez-Barraza, Smith, & Dahlgaard-Park, 2012). LP is a management system focused on waste elimination and value creation for all stakeholders; it can be applied to and improve the performance and competitiveness of health services (Hicks, McGovern, Prior, & Smith, 2015; Zidel, 2006).

Literature on LP is quite vast, but the information on how to implement it is not clear, making it difficult to identify which techniques or methods are more appropriate to its application to health operations. + analyzed five LP implementation processes in two Brazilian hospitals, but they did not detail the sequence of LP implementation stages, or extracted experiences that could be translated into guidelines to help LP implementation in other health operations. Moreover, most studies about lean healthcare are not comparative, mostly consisting of isolated case studies (Radnor, Holweg, & Waring, 2012).

The aim of the present study was to analyze the process of LP implementation in three Brazilian hospitals that played a pioneering role in its application, to identify common experiences that can be used to define guidelines for LP application to hospitals, and to contribute to literature on lean healthcare, which has limited details regarding its implementation.

The present study is structured as follows: following the present introduction, a brief theoretical background on lean healthcare is presented. This is followed by the description of the methodological procedures, and the presentation of case studies. The results are discussed, and LP implementation guidelines (here called "lessons learned") are extracted. Finally, the conclusions are presented.

LEAN HEALTHCARE

Shingo (1996) defines LP as a production management system aimed at the complete elimination of waste. Waste consists of activities that consume resources, generate costs, and do not add value to the product (Ohno, 1997; Shingo, 1996). LP is also considered a management strategy that can be applied to services, as its principles may improve the processes of any organization (Womack, Byrne, Fiume, Kaplan, & Toussaint, 2005).

LP includes a set of principles and methods. The principles are related to the philosophy of the company and constitute the pillars that guide lean strategic actions, and the methods are the means through which the principles are met and maintained (Godinho, 2004). The principles are: to determine the value for the client, define the value stream, maintain a continuous flow, pull production, integrate the supply chain, focus on quality, visual management, use technology that serves employees and processes, human resource development, and continuous improvement (Godinho, 2004; Liker, 2008; Shingo, 1996; Womack et al., 2005; Zidel, 2006). The methods are: value stream mapping (VSM), just in time, *kanban*, autonomation (*jidoka*), 5s, standardization, workload leveling (*heijunka*), group technology and cellular layout, *takt* time synchronization, quick changeover (Single Minute Exchange of Die [SMED]), zero defects quality control, total productive maintenance, visual control, teamwork and multifunctional workers, empowerment (autonomy), and *kaizen* (Godinho, 2004; Liker, 2008; Womack et al., 2005). VSM is widely used in both manufacturing and services. According to Rother and Shook (2003), who created this method, it can be used to map all material and information streams, and is used for communication, business planning and management of change, and improvement processes.

Hospitals are complex organizations, dedicated to diagnosis and patient treatment. Hospitals, therefore, prevent diseases, promote health, enable professional practice and training, and develop research (Malagón-Londoño, Morera, & Laverde, 2000). LP considers that the main process is the one that creates the value desired by the client. In the case of hospitals, the main processes are those aimed at health recovery (technical processes), and the remaining processes support the central service (Aronsson, Abrahamsson, & Spens, 2011; Kollberg, Dahlgaard, & Brehmer, 2007; Meredith, Amy, Paul, Fraser, & Mairi, 2011).

Emergency departments present the highest number of reported LP applications (Holden, 2011), because they are considered highly inefficient (Dickson, Anguelov, Vetterick, Eller, & Singh, 2009), with several problems that must be solved,

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such as overcrowding, delays, low quality care, low patient safety, and high costs (Holden, 2011). Nonetheless, because it has steady demand, LP application is easier. For example, Ben-Tovim et al. (2008) described LP application in an Australian hospital, beginning in the emergency department and later being expanded to other departments, which included three phases: acquiring technical knowledge, stabilizing high-volume flows, and standardizing and sustaining the changes. As a result, there was an increase of 40% to 80% in the number of patients that stayed in the emergency department for only one day, an increase in the number of patients seen in the emergency department, and a decrease in the number of patients that left the emergency department because of delays in service.

LP has also been applied to surgical processes, such as in Teichgräber and Bucourt (2012), who studied the process of procurement of endovascular stents in interventional radiology services. Following VSM application, it was observed that out of the 13 processes for the procurement of stents, only two were value-adding, five were unnecessary, and six were necessary but not value-adding. The authors drew a VSM for a desirable future state, which eliminates waste through pull production.

Sullivan, Soefje, Reinhart, McGeary, and Cabie (2014) studied LP implementation in the oncology pharmacy of a hospital in the United States, which was expanding its chemotherapy department and needed to increase the capacity of its pharmacy owing to increased drug volume. After VSM implementation, six steps were eliminated that were not value-adding, decreasing the stream lead time from 91 to 71 minutes.

LP has been applied to many other processes, such as hospital stays (Carter et al., 2012), outpatient services (Laganga, 2011), laboratories (Papadopoulos, Radnor, & Merali, 2011), radiology services (Kruska, Reedy, Pascal, Rosen, & Boiselle, 2012), and nursing services (Mizuno, Yoshikawa, Yomogida, Morio, & Sakai, 2012; Radnor et al., 2012; Toussaint, 2009).

These studies reported positive results of LP implementation, but they focused on the separate application of lean techniques, that is, on specific processes. Studies of systemic implementations of LP associated to strategic planning, thus, have not been reported (Burgess & Radnor, 2013; Radnor et al., 2012). These studies also show a predominance of VSM and *kaizen* application (Ben-Tovim et al., 2008; Dickson et al., 2009; Holden, 2011; Ng, Vail, Thomas, & Schmidt, 2010; Radnor et al., 2012; Tejedor-Panchon et al., 2014). Therefore, although the available literature is encompassing in reporting the application of lean techniques, it leaves a gap regarding their integration in a full lean healthcare implementation process.

Following the analysis of the literature on lean healthcare, certain elements discussed in the studies were identified and used to define different research categories related to LP implementation in hospital operations (Exhibit 1).

Exhibit 1. **Research categories**

Categories	Implementation process	Authors
History and trajectory of implementation	- Motivational factors - Implementation structure	Bertani (2012); Carter et al. (2012). Radnor et al. (2012); Burgess and Radnor (2013).
Implementation of lean techniques	- Process waste - Hospital processes versus lean techniques - Results achieved - Difficulties	Jimmerson (2010); Graban (2013); Ben-Tovim et al. (2008); Teichgräber and Bucourt (2012); Laganga (2011); Sullivan et al. (2014).
Development of improvement culture	- Human resources training - Commitment to human resources	Bertani (2012); Papadopoulos et al. (2011).

RESEARCH METHOD

The present study requires an in-depth and exhaustive analysis of the whole LP implementation process, for which qualitative case study is an adequate method. Three hospitals (identified as A, B, and C), located in the state of São Paulo and which had publicly declared to have adopted LP, were selected. In the case selection, the possibility of obtaining similar results (Yin, 2005), leading to the identification of common elements to different implementation processes, was also considered. Following the case selection, the overall information for the three hospitals was summarized (Exhibit 2. The date of the beginning of LP implementation, among others, is presented in this table.)

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Exhibit 2. **General case information**

Information	Cases		
	A	B	C
Type	Medium-sized philanthropic	Large-sized private (private services or agreements)	Private
Founding year	1920	1945	1995
Employees	600	1650	150
Services	Oncology (cancer treatment: surgeries, chemotherapy, radiotherapy, and tests) by the Unified Health System (Sistema Único de Saúde - SUS)	Foco em cardiologia, neurologia, Focused on cardiology, neurology, oncology, emergencies, trauma/orthopedics, and kidney, pancreas and liver transplants; performs transplants and tests by the SUS. Teaching and research institute	Specialized in cancer diagnosis and treatment Responsible for the oncology service of a state hospital (Hospital C1)
Characteristics	Two buildings: outpatient (capacity for 210 appointments per day) and hospital (76 beds and 4 surgical rooms)	30 mil m² area, 258 operational beds, 68 ICU beds, capacity for 1,000 surgeries/month, 1,160 admissions/month and 6,050 emergency attendances/month	No information
Beginning of LP	2011	2013	2008

A multiple case study approach was adopted, because it provides more convincing results than single case ones (Yin, 2005). The cases acted similarly to multiple experiments, presenting similar results, permitting literal replication and, therefore, external validation (Yin, 2005). The results were also based on data obtained from multiple sources (semi-structured and unstructured interviews; documents such as magazine news stories and internal documents; and *in loco* unsystematic observations), leading to construct validity (Yin, 2005).

To increase reliability, a protocol was developed using the data collection tools adopted and other general information (Yin, 2005); the research categories were used to develop the interview script (Exhibit 1). Interviews were administered to managers, as presented in Exhibit 3. Other details of data collection are also presented in Exhibit 3.

Exhibit 3. **Data collection**

Case	Interviewees	Collection tools	Duration of the interview
A	Quality coordinator	Semi-structured interviews, document analysis, and unsystematic observations	1h30 and 1h
	Radiotherapy coordinator		1h05
B	Quality coordinator		2h30 and 30min
C	Quality manager	Non-structured interviews, unsystematic observations	1h05

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All interviews were recorded and transcribed. Data were analyzed within-case (how each hospital implemented LP) and cross-case (different cases were compared and contrasted; the results were compared with the theory; and lessons learned were identified.) (Yin, 2005). The data were synthesized and interpreted using content analysis, which enabled the identification of study categories based on the theoretical framework. Content analysis is a method of text and transcribed speech analysis that seeks to analyze the content of text in a systematic, objective, and reliable manner, by coding the text into predefined categories (Papworth, Milne, & Boak, 2009).

RESULTS

Hospital A

Motivation for LP implementation emerged when a consulting company contacted the hospital director and offered free services for one year in exchange for experience with lean healthcare implementation. The hospital accepted, and after one year, hired the consulting company, which had remained in service until February 2014. Lean culture is currently developed by the hospital employees under the supervision of quality management.

LP implementation was linked to strategic planning, with lean targets compatible with strategic ones. In the beginning of LP implementation, a balanced scorecard (BSC) was developed and focused on outpatient and specialized medical services (OSMS), chemotherapy, radiotherapy, and tests. The BSC goals were related to LP from four perspectives: clients, internal processes, knowledge and apprenticeship, and financial.

LP implementation was performed using the define, measure, analyze, improve, and control (DMAIC) methodology (it was used in Six Sigma projects for improvement project management), beginning with the chemotherapy patient flow (key-service for cancer treatment and profitability). The targets for the first lean project were: to decrease waiting time, increase process capacity, and structure the sector. The project was later extended to radiotherapy processes.

Awareness and training sessions were performed for three months, with the employees involved in chemotherapy patient flow. Initially, the manager and chief nurse were trained, and subsequently the remaining employees. Training sessions were performed in one day or one week, and included both theoretical and practical components (the practical component consisted of improvement projects). The training sessions did not have a set periodicity but were performed as further adjustments, or new improvement projects were needed.

The first methods implemented were VSM and *kaizen*. Losses were identified in chemotherapy and radiotherapy processes through VSM, and lean techniques were applied to eliminate them (Exhibit 4).

Exhibit 4. **Lean techniques – Hospital A**

Process	Techniques	Results
Chemotherapy	VSM, *kaizen*, 5S, workload leveling, standardization, team work and multifunctional workers, visual control, and zero defect quality control.	Increase of 23% in the capacity of chemotherapy application. Decrease of patient waiting time for chemotherapy infusion to 1 h. Decrease in the time of seat loading of 40 min.
Triage	VSM, *kaizen*, workload leveling and standardization.	*
Authorization of High Complexity Procedures (Autorização de Procedimentos de Alta Complexidade [APAC])	VSM, kaizen, standardization.	Decrease of 74%, or up to 28 days, in patient lead time.
Reception	VSM, *kaizen*, 5S, standardization, and zero defect quality control.	*
Patient record control		
Laboratories		Decrease of 90% in test deadline.
Pharmacy	5S, standardization, and zero defect quality control.	Increased productivity in drug handling.
Radiotherapy	VSM, *kaizen*, standardization, visual management, 5S, SMED, zero defect quality control.	Decreased waiting time from 50 min to 20 min. Creation of a reception.

* Processes with results that were not described.

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After LP implementation, chemotherapy treatments at the hospital started to be scheduled adequately: the patients that required longer chemotherapy duration began being assigned to the first hours of the day, which decreased the waiting time from four hours to one hour. Regarding radiotherapy processes, before LP implementation the employees had to perform bureaucratic and administrative functions and monitor the radiotherapy treatments, which increased the time of application cycle and the patient waiting time. After LP implementation, a reception room and dressing rooms inside the treatment rooms were created (so that, as one patient is leaving the machine, another is already changing to enter it – reduced setup). These changes decreased the patient waiting time from 50 min to 20 min.

Improvement sustainability was obtained through standardization of activities, definition of responsible staff and project targets, and monitoring of performance indicators (established before the interventions). DMAIC enabled improvement sustainability as the improvements were implemented and subsequently analyzed, beginning a new improvement cycle.

Hospital B

The motivation for LP implementation came from the senior management, which realized the need for revising processes and hired an employee to implement LP (quality coordinator). The set targets were the provision of health services of excellence and reduction of internal costs, thereby increasing operational efficiency and market competitiveness. A consulting company referred by Johnson & Johnson, the hospital supplier of surgical thread, was hired for six months. LP is currently developed by the hospital employees under the supervision of the quality management.

LP implementation was linked to strategic planning, which was developed by the senior management and operational managers, and inscribed within the Enterprise Resource Planning (ERP). LP was linked to strategic planning by being included as an action to achieve the set goal (increase productivity of all processes, and thus decrease costs). The DMAIC method of improvement was also adopted within the implementation structure.

Several awareness sessions were initially conducted with the managers, and the flow of patients subjected to a video-assisted elective surgery was subsequently selected as the scope of the first project, because it is a high-volume surgery. The professionals involved in this flow needed to be trained and capacitated to implement LP techniques. The hospital has a continued education sector that plans training sessions for lean project execution. The quality management administers these theoretical and practical training sessions using lean projects and a pasta factory simulation using robots made out of assembly toys. The initial focus was 5S and the seven wastes of LP (overproduction, transportation, over-processing, defects, inventory, motion, and waiting). Currently, 30% of the employees have been trained, and all employees have received the first instructions on LP upon admission, with the goal of developing the culture of continuous improvement.

The first improvement project was composed of 12 subprojects, encompassing the whole flow of patients subjected to an elective video-assisted surgery (from surgery scheduling to patient discharge). Each project was executed by a multidisciplinary team that worked on surgical flow process to develop the following projects: surgery scheduling; patient reception; bed management; patient admission at the admissions unit; patient discharge (from when the doctor prescribes the discharge to the patient exiting the hospital, room cleaning, and room release to a new patient); surgery center: sterilization center, post-anesthesia recovery; lean room; improvement of patient transportation (transportation from the reception to the admissions unit, from the admissions unit to the surgery center, and from the admissions unit to the laboratory for tests); information flow; supply redesign; orthoses, prostheses, special material (OPSM) flow, considered a high-cost flow; overall maintenance (focused on scheduling preventive equipment maintenance); and visual management.

The scope of all projects, participants, and targets was defined previously, and an annual gain of BRL 34.5 million in cost reduction was predicted, of which BRL 25 million accounts for the surgical process alone.

Supplier, input, process, output, and customer (SIPOC), which consists of the description of these features for a macro-understanding of processes, was used before LH implementation. Subsequently, it was applied the Voice of Customer (VOC), which involves talking with the main clients regarding the quality of the goods or services provided. *Kaizen* and VSM were then implemented, followed by 5S (after 5S, five tons of waste equipment and paper were removed). The relationship between the implemented techniques and the results obtained for the flow of patients subjected to an elective video-assisted surgery is presented in Exhibit 5.

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Exhibit 5. **Lean techniques – Hospital B**

Processes	Techniques	Results
Surgery scheduling	VSM, *kaizen*, 5S, standardization, workload leveling, takt time synchronization, zero defect quality control, and cellular layout.	Decreased waiting time, decrease of 28% in the number of cancelled surgeries.
Patient reception	VSM, *kaizen*, 5S, standardization, takt time synchronization, visual control, and zero defect quality control.	Decreased waiting time.
Bed management	VSM, *kaizen*, 5S, standardization, workload leveling, takt time synchronization, zero defect quality control, and visual control.	Decreased bed turnaround time from 5 h 30 to 2 h 30, growth of 300% in the number of opened vacancies and decrease of 56% in the time of bed cleaning.
Patient admission in the admissions unit	VSM, *kaizen*, 5S, standardization, takt time synchronization, visual control, and zero defect quality control.	Decreased times.
Release process		*
Surgical center: sterilization central, post-anesthesia recovery	VSM, *kaizen*, 5S, standardization, takt time synchronization, zero defect quality control, autonomation, SMED, total productive maintenance, visual control, cellular layout.	Lean room project (through a pilot, decrease in turnaround time from 100 min to 16 min), elimination of pharmacy rework.
Patient transportation	VSM, *kaizen*, 5S, standardization, takt time synchronization, total productive maintenance, zero defect quality control.	*
Information flow	VSM, *kaizen*, 5S, standardization, takt time synchronization, visual control, zero defect quality control.	*
Supplies	VSM, *kaizen*, 5S, cellular layout, standardization, takt time synchronization, zero defect quality control, visual control, kanban.	Decrease of 3% in inventory, deactivation of the pharmacy that supplied ICUs, and creation of a new ICU with 10 beds. Deactivation of four satellite pharmacies and use of bedside carts.
OPSM flow	VSM, *kaizen*, 5S, standardization, takt time synchronization, visual control, and zero defect quality control.	*
Invoice central	Group technology and cellular layout.	*
Billing		*

* Processes with results that were not detailed in the field research.

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When the traditional surgery room was used, the pharmacy supplied a cart with the basic drugs, and a nurse was required to fetch the necessary drugs and materials. Among the improvements in the surgical process was the development of a lean room containing a supermarket (cabinet) where the drugs and materials necessary for the five surgeries were stored. This decreased the setup time from 100 min to 16 min. Markings in the surgical room were also created, which facilitated the easy cleaning process, and cleaning started during the surgery (decreasing the setup time between surgeries).

LP implementation was supported by the management (although there was resistance from the employees, with nurses being the most resistant, especially in the ICU). This resistance was overcome through training sessions and daily supervision. Performance indicators were also established to evaluate the results achieved and sustain the improvements.

Hospital C

Between 2006 and 2007, the hospital underwent certification by ONA, and the preparations to meet the certification requirements increased the lead times, costs, and volume of documentation. The director realized that the processes were confusing and complex, and that the volume of documentation had become the greatest obstacle; thus, he decided to look for information on waste in health systems.

The director consulted the study by Womack et al. (2005), and understood that processes could be improved, thereby increasing quality and efficiency. Therefore, he established a partnership with the Lean Institute Brasil (LIB), which had not previously performed lean healthcare implementation. With the support of LIB, the director began participating in events promoted by, among others, Volkswagen, GM, Embraer, and 3M, as well as conferences in the US; subsequently, he attended training courses in Canada. Hospital C is currently a Lean Healthcare Black Belt according to the Logistics Institute Canada.

Lean healthcare implementation was linked to strategic planning, and its aims were to improve the quality of patient care, expedite processes, and eliminate waste. The implementation began with the use of the plan, do, correct, and act (PDCA) method, and a pilot project in Hospital C1 was aimed at increasing the outpatient capacity. The first methods implemented were *kaizen* and VSM. After certain improvements, the agility of service increased by 25%. The increase in outpatient capacity generated bottlenecks in, among others, emergencies, admissions, and imaging center; the hospital also realized that improving a given process was not sufficient, but the improvements must include the whole value chain.

Therefore, projects started with an aim to improve the whole chain. Currently, there are more than 80 improvement projects currently performed in Hospital C1, which is only responsible for oncological treatments, and all its units. In Hospital C1, the most pronounced result was a 170% increase in consultation capacity, without expanding the physical area or number of employees, with a decrease in overtime higher than 40%.

The target of all projects is decreasing waste in at least 50%, and the following waste decreases were observed: (i) 30% in the reception process in one of the clinics; (ii) 90% in the invoice process; (iii) 70% in inventory; (iv) 80% in billing; and (v) waiting time in radiotherapy from 2 hours and 30 minutes to 1 hour. It is highlighted that the project for the radiotherapy process increased machine efficiency from 44% to 70%.

Kaizen improvement groups are created when a problem is detected, all staff involved is called to participate in them; the result is an A3 report (tool to propose solutions).

VSMs were focused on increasing process safety (eliminating mistakes and waste, and therefore increasing quality). The implementation of the future state is usually performed using other lean techniques. In the case of Hospital C, the following were adopted: 5S, standardization, visual control, multifunctional workers, and zero defects quality control.

Hospital C held training sessions that combined theory and practice (the practical component consisted of improvement projects; theory was provided by LIB). In 2009, the executive director administered a 40-hour course on LH for 16 employees; afterward, the team developed four projects. Another team was qualified in 2010, and focused on developing the improvement culture instead of specific projects.

In 2013, Hospital C established a society with a hospital from the Rede D'or network, and took over three additional radiotherapy units. The LH management of Hospital C must, therefore, keep people developing lean improvements in its units, and at the same time improve the new units. Hospital C obtained help from LIB, which conducted the expansion of LH implementation and the training of flow coordinators.

Currently, Hospital C possesses assistance, organization and work, material and equipment, and information flow coordinators, who are responsible for improvements in the whole hospital chain. It also has a visual management board (routine management) in all its processes, in which security alerts (reports are filled when errors occur) and improvement ideas are included. On a weekly basis, the flow coordinators, together with the process team, analyze problems and ideas, as well as may

generate *kaizen* events and/or A3 reports. If *kaizen* is needed, the problems raised are reported to the quality management who holds the *kaizen* event together with flow coordinators.

The hospital implemented visual control. In addition to routine management, it adopted tables with: monitoring of performance indicators (based on the four dimensions of care: people, safety, quality, and efficiency), medical record tracking, billing control, preventive maintenance, control of reception activities, and control of several processes throughout the workplace, such as daily rounds (standardized questions based on the four dimensions of care), work instructions, monthly performance, and failure, mode, and effects analysis (FMEA) (a systematic tool that enables the identification and prevention of problems) in the reception process (Exhibit 6).

Exhibit 6. **Lean techniques - Hospital C**

Process	Techniques	Results
Reception	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control, team work, and multifunctional workers.	Decrease of 30% in waste.
Invoice central	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control.	Decrease of 90% in waste.
Supplies	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control.	Decrease of 70% in inventory.
Billing	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control, team work, and multifunctional workers.	Billing in real time.
Outpatient	VSM, *kaizen*, visual control, 5S, standardization, and zero defect quality control.	Increase of 170% in appointment capacity.
Pharmacy		*
Laboratories		
Emergencies		
Chemotherapy		
Radiotherapy	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control, and SMED.	Decreased waiting time for radiotherapy from 2 h 30 to 1 h Increased efficiency of radiotherapy machines from 44% to 70%.
Maintenance	Visual control, 5S, standardization, and zero defect quality control.	*
Laundry	5S.	*

* Processes which results were not described.

DISCUSSION AND LESSONS LEARNED

LP implementation presented many similarities in the three studied cases; for example, the VSM application enabled the identification of activities that did not add value to the processes, resulting in decreased lead time (namely, in chemotherapy and radiotherapy processes in Hospital A) and decreased setup of surgical processes (Hospital B).

LP implementation was associated with strategic planning in all cases, using cyclical continuous improvement tools (PDCA in case C, and DMAIC in cases A and B). Theoretical and practical training sessions, which were organized by consulting companies and quality managers, were also performed. The senior management was involved, with LP implementation being initiated owing to problems in high volume processes or essential to profitability. Improvement projects with limited scope were developed; participants were selected; and targets were defined. Although the projects had a target, and consequently a beneficial result, the senior management focused on implementing LP systemically and developed a cultural change, thereby promoting the assimilation of continuous improvement culture.

Because they enable the identification of process waste, projects began with the application of VSM, together with *kaizen*. The operations intervened in the processes, simultaneously implementing other lean techniques. LP implementation began with a different process in each hospital: chemotherapy patient flow in Hospital A, surgical patient flow in Hospital B, and outpatient process in Hospital C. The processes with higher application of lean techniques are presented on Exhibit 7.

Exhibit 7. **Processes and implemented techniques**

Process	Hospital	Techniques applied	Number of techniques
Chemotherapy	A	VSM, *kaizen*, 5S, workload leveling, standardization, team work and multifunctional workers, visual control, and zero defect quality control.	8
	C	VSM, *kaizen*, visual control, 5S, standardization, and zero defect quality control.	6
Radiotherapy	A	VSM, *kaizen*, standardization, visual control, 5S, zero defect quality control.	6
	C		
Laboratories	A	VSM, *kaizen*, 5S, standardization, and zero defect quality control.	5
	C	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control.	6
Pharmacy	A	5S, standardization, and zero defect quality control.	3
	B	VSM, *kaizen*, 5S, cellular layout, standardization, takt time synchronization, zero defect quality control, visual control, kanban.	9
	C	VSM, *kaizen*, visual control, 5S, standardization, and zero defect quality control.	6
Reception	A	VSM, *kaizen*, 5S, standardization, and zero defect quality control.	5
	B	VSM, *kaizen*, 5S, standardization, takt time synchronization, visual control, and zero defect quality control.	7
	C	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control, team work, and multifunctional workers.	7
Invoice central	B	Group technology and cellular layout.	1
	C	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control.	6
Billing	B	Group technology and cellular layout.	1
	C	VSM, *kaizen*, visual control, 5S, standardization, zero defect quality control, team work, and multifunctional workers.	7

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Figure 1 was built based on the case analysis, and presents the common experiences on "how" the LP implementation process occurred. Guidelines for lean healthcare implementation were extracted from Figure 1; these may help hospital operations improve care quality and efficiency.

- Lean healthcare implementation must include patient, material, and information flows. Patients are processed in, among others, surgery, emergency, chemotherapy, and outpatient processes. Materials are processed in warehouse, pharmacy, laboratories, OPSM, and laundries. Information is the focus of changes in medical record, surgical scheduling, bed management, and invoice and billing central control processes.

- Contracting specialized consulting services. An external view may be a key factor to the success of lean healthcare implementation, especially in organizations where the technical staff has no experience with lean philosophy. In Hospital A, lean healthcare implementation began with the direct help of consultants and continued for three years; Hospital B had the help of a consulting company in the initial phase of implementation. In Hospital C, direct participation of consultants only occurred six years after the beginning of lean healthcare implementation, at the time of its expansion.

- Establishing improvement teams (*ad hoc*) and a fixed process management team. *Ad hoc* teams were established in the three hospitals to conduct the projects. In Hospital A, a fixed team was trained to lead lean healthcare implementation from the beginning. Hospital C also established a fixed team for this purpose, composed by a quality manager and four flow coordinators.

- Linking lean healthcare to strategic planning to promote higher commitment. Lean healthcare implementation was linked to strategic planning, thereby increasing its efficiency through actions to achieve performance targets. This may be performed by the fixed team responsible for managing lean healthcare implementation, by the consulting company and managers in improvement teams.

- Adopting cyclical continuous improvement tools: PDCA, or DMAIC. The operationalization of PDCA and DMAIC is analogous, and therefore both pilot and other projects can be performed efficiently using these tools.

- Improvement projects must be performed for critical processes, defining scope and targets. In all studied cases, senior management decided to begin LP implementation with processes considered problematic, of high volume, or essential to profitability, based on daily coexistence with the processes and available indicators. LP implementation was operationalized through improvement projects with defined scope, participants and targets, and the support of the senior management.

- Conducting theoretical and practical training sessions. The practical component may consist of knowledge application through improvement projects.

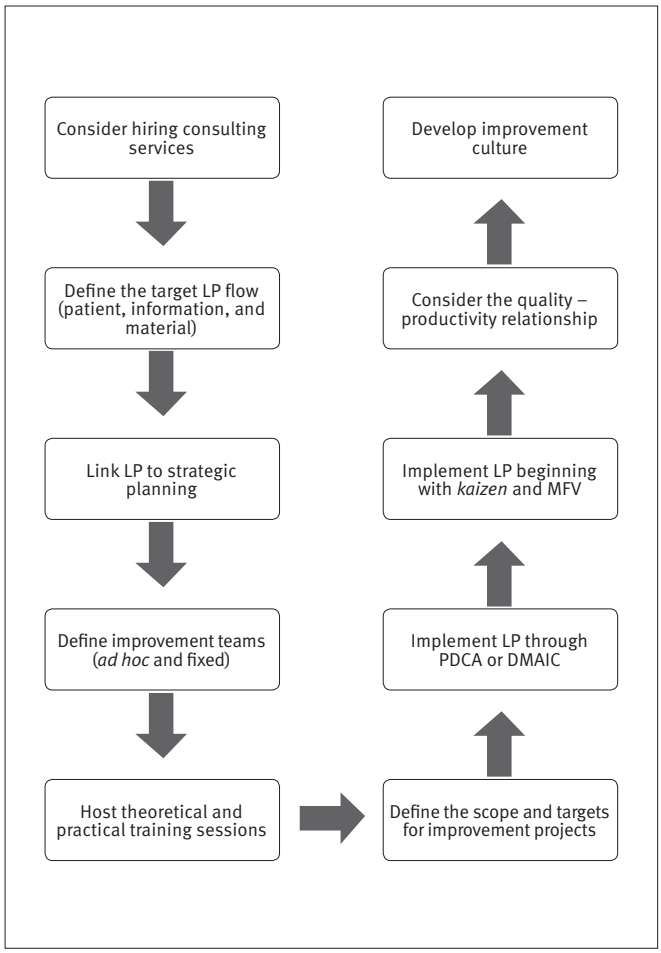
- The first methods applied must be *kaizen* and VSM. VSM was used to identify process waste. The studied hospitals then performed interventions to eliminate or decrease process waste, and simultaneously implemented other methods (5S, standardization, workload leveling, visual control, zero defects quality control, etc.).

- LP implementation must consider the quality-productivity relationship. The safety of processes and patients must be prioritized; that is, productivity increases are only viable if they do not negatively affect quality.

- Developing the continuous improvement culture. Although the projects had targets, and consequently results, the focus of the senior management was to implement LP systemically and effect a cultural change, promoting the improvement culture.

In agreement with previous reports, the studied cases showed that LP implementation encompasses patient, material, and information flows. Because hospitals are complex organizations, LP success would be difficult if it focused only on the improvement of one type of flow. Although patient flow is the most representative in certain cases, its performance would not be good without the support of material and information flows.

Figure 1. **Common experiences in LP implementation**



Regarding the implementation structure, Bertani (2012) suggested the formation of *ad hoc* teams, and a fixed internal team to manage the whole process. In agreement with previous reports, these teams were formed and conducted the projects in the three studied cases. In agreement with Costa et al. (2015) and Bertani (2012), employee commitment was the critical factor for LP implementation in the three studied cases. In addition, as suggested by Zidel (2006), LP implementation began with the contracting of a consulting company.

CONCLUSION

The aim of the present study was to analyze LP implementation in three hospitals, to identify common experiences from which guidelines for lean healthcare application could be extracted. The data reported in the consulted literature did not allow to understand the process of LP implementation in health services. Hence, among the contributions of the present study was the analysis of the process underwent by the hospitals in search for a lean management model.

The present study allowed to connect the existing studies, which usually showed lean healthcare implementation divided in parts (either focusing on a given technique or emphasizing positive results), but it did not give an overall view of the whole process. The in-depth analysis of the LP implementation process allowed the identification of some determinant factors for the success of lean healthcare, and helped building a conceptual basis for this process.

The studied cases presented certain similarities with the consulted literature, which considers that *kaizen* and VSM should be the first lean techniques implemented (Carter et al., 2012; Dickson et al., 2009; Laganga, 2011; Teichgräber & Bucourt, 2012). However, the empirical evidence in the present study is in contrast with Radnor et al. (2012) and Burgess and Radnor (2013), who stated that LP implementation is not systemic or linked to strategic planning. In the studied cases, LP implementation was linked to strategic planning, and aligned with operational goals and the development of continuous improvement culture.

The present study may help hospitals and managers that wish to implement LP, helping them to develop lean culture and improve patient care quality, decrease costs, and increase process efficiency. The present study may also help the managers of the studied hospitals to understand how LP implementation occurred in their hospitals, and make future improvements from the lessons learned in their trajectories.

Another contribution of the present study was the presentation of 10 guidelines (lessons learned) for lean healthcare implementation. Based on these guidelines, further studies may be performed to elaborate a methodology of LP implementation in hospital operations.

The present study presented limitations, one of them being that the resources necessary to LP implementation were not identified. It is therefore suggested that the most important resources to lean method implementation must be identified from a resource-based viewpoint, in order to identify which resources must be developed and improved. This may also be extended to the hospital supply chain, which affects directly the success of LP implementation and must be studied.

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