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LEAN PROCESS IMPROVEMENT IN HEALTHCARE: A STUDY USING VALUE STREAM MAPPING, THEORY OF CONSTRAINTS AND SIMULATION

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ABSTRACT

In healthcare services, where human health is the primary concern, the principle of "doing it right the first time" is paramount. Waste and constraints in service delivery processes can directly impact patient health outcomes. This study aim is to examine the hospitalization process of the internal medicine department of an education and research hospital using value stream mapping (VSM), theory of constraints (TOC) and simulation (using Arena software). Initially, current and future patient flows were mapped using VSM. Constraints affecting these flows were determined using TOC, while simulation was used to assess the impact of a lean model on the system proposed through the future state map (FSM). Two scenarios were developed for the future state. The findings show the presence of numerous non-value-added steps in the existing system. A leaner patient flow was achieved by minimizing these inefficiencies through the proposed future state models, addressing problematic areas that hinder the flow. Non-value-added time (NVAT) was reduced by 44 percent in the first proposed scenario and by 72 percent in the second proposed scenario. Patients' length of stay (LoS) improved by 1 percent with the first model and decreased by 12 percent with the second model. Additionally, transfer time (TT) was decreased by 88 percent in the first scenario and by 92 percent in the second scenario. This study offers valuable insights and can serve as a roadmap for researchers, managers and decision-makers in the healthcare sector seeking to implement lean practices.

Keywords: Lean production, simulation, theory of constraints, value stream mapping, process improvement.

INTRODUCTION

In 2019, health expenditures across European Union (EU) countries averaged 8.3 percent of gross domestic product (GDP). This figure exceeded 11 percent in Germany and France, while it was below 6 percent in Luxembourg and Romania. North Macedonia was among the countries with the lowest share, at 6.1 percent, and Türkiye had the lowest share at just 4.4 percent. Across Europe, Switzerland had the highest share, dedicating 12.1 percent of its GDP to health spending. In many countries, a large amount of health expenditures is allocated to treatment and rehabilitation services. In addition, pharmaceutical expenses represent a considerable part of health expenditures, especially in some Central and Eastern European countries (The Organisation for Economic Co-operation and Development [OECD], 2020). The emergence of Covid-19 in 2020 led to major disruptions in the healthcare system. According to the OECD's 2022 report, per capita health expenditure in EU countries increased by an average of 5 percent in 2020 due to the impact of the pandemic. The increase was over 10 percent in Hungary, Bulgaria and the Czech Republic, while Switzerland remained the top spender in Europe. On the other hand, countries such as Romania and Croatia had the lowest health expenditures (OECD, 2022).

In 2020, health expenditure per capita in EU countries increased by 5.5 percent compared to 2019, reaching the highest growth rate since 2004 (OECD, 2022). Healthcare involves the collective effort to finance, secure and deliver health services through private or public healthcare institutions (Donev et al., 2013).

Lean thinking, first introduced in the 1950s by the Toyota Motor Company as the Toyota Production System (TPS), was later refined by Womack and Jones. Lean thinking is based on the principle of meeting customer needs quickly, efficiently and with minimum waste (Young et al., 2004). Lean philosophy focuses on eliminating activities that do not add value from the customer’s perspective. These wastes are classified into seven areas: transportation, inventory, motion, waiting, overproduction, over processing and defects (Waring & Bishop, 2010). Lean is a practical approach to improve processes that identify and eliminate non-value-added activities, thereby enhancing customer-oriented performance (Assen, 2018).

Today, lean thinking is recognized globally, with applications ranging from product and service production to healthcare service delivery. Among the various process improvement approaches, lean production (LP) practices and principles have gained widespread acceptance in the health management field (Brandao De Souza, 2009). Lean health (LH) service applications offer several benefits including shortened waiting times, enhanced service delivery, elimination of repetitive processes, improved interdepartmental relations, and increased employee motivation (Radnor & Walley, 2008).

The aim of this study is to examine the hospitalization process at an education and research hospital using lean thinking principles. The process improvement was conducted using value stream mapping, theory of constraints and simulation methods. Value stream mapping was employed to analyze the process, identify constraints and highlight waste. The root causes of these constraints were determined using the theory of constraints thinking process. The impact of the proposed process improvements was then analyzed using simulation. These methods were chosen to ensure a comprehensive analysis of the process and to provide effective solutions. The research was carried out in the internal medicine department, which has the highest patient flow in the hospital. A review of existing studies reveals that no process improvement study in the healthcare sector has integrated value stream mapping, theory of constraints, and simulation methods simultaneously. Thus, the findings of the study are expected to guide healthcare managers and researchers interested in this field.

LITERATURE REVIEW

Value Stream Mapping

Lean is a methodology developed by Toyota Motor Company to achieve operational excellence. Lean principles enabled the company to improve process efficiency in the early twentieth century by eliminating various types of waste (Jayamohan & Bhasi, 2024: 655). The main purpose of lean thinking is to eliminate waste in both production and service processes. Lean thinking has five main principles: value, value stream, flow, pull and excellence. Value defines the needs of the end consumer, as perceived from their perspective. Once value is defined, the next step is to determine the value stream, which is important for identifying waste in a particular product or service process (Womack & Jones, 1996).

Value Stream Mapping (VSM) is a pictorial presentation using standard symbols to map the flow of materials and information (Vinodh et al., 2016). VSM is a key tool for guiding lean transformation. It focuses on mapping the current process by visiting the gemba (the actual production area) (Bicheno & Holweg, 2016). Generally, VSM consists of four main steps: (i) selecting a product/service family, (ii) creating the current state map (CSM) to indicate the current production or service process, (iii) Drawing the future state map (FSM) and (iv) preparing an implementation plan to achieve the desired future state (Krajewski et al., 2013). Once the value stream is mapped, non-value-added steps in the process emerge (Simons & Zokaei, 2005).

Theory of Constraints

The Theory of Constraints (TOC) is a method developed from Goldratt's "Optimized Production Timelines" system (Rahman, 2002). According to Goldratt, TOC is based on a process of continuous improvement, offering an intuitive structure for managing a business (Goetsch & Davis, 2016). TOC addresses three key questions: What to change? What to change to? and How to change? (Goldratt & Cox, 2012).

According to the TOC, there is at least one constraint that affects the efficiency of each system. By improving the identified constraint, the overall performance of the system can be improved (Amonge, 2015). TOC is a management philosophy aimed at increasing system efficiency and performance by identifying and addressing bottlenecks that constrain processes (Mohammadi & Eneyo, 2012). There are various types of constraints that affect system performance. These are classified as behavioral, managerial, capacity, material, market and logistics constraints (Murphy & Dedera, 1996). The system can be visualized as a chain, where the performance of the chain is limited by the weakest link. Therefore, TOC focuses on the processes that slow down the system’s flow (Nave, 2002).

TOC consists of a five-step application: (i) identify the constraint, (ii) decide how to use the constraint, (iii) align all decisions taken to support the chosen approach (made in the second step), (iv) eliminate the constraint, and (v) return to the first step and repeat the process (Blackstone, 2001).

Simulation

Simulation is defined as the process of reproducing the behavior of a system using a model that represents its processes (Krajewski et al., 2013). Simulation is widely regarded as the most appropriate method for identifying problem areas, understanding the cause of problems, making informed decisions, finding the most appropriate solutions, and translating research findings into real-world applications (Brahmadeep, 2014). A simulation study involves a series of structured steps. The first step is to gain a thorough understanding of how the system works. This is followed by defining realistic objectives, formulating the model, running the simulation, verifying and validating the model, designing and running the experiment, analyzing the results and documenting the findings (Kelton et al., 2002).

Lean Production (LP) tools, initially launched by Toyota as part of the TPS, focus on establishing standardized and stable processes to deliver high-quality services and products efficiently. Lean adopts a continuous improvement strategy aimed at creating straightforward processes and eliminating waste within the system (DelliFraine et al., 2010).

When examining the literature, it becomes evident that numerous process improvement studies have been carried out using lean thinking techniques. Lean has been applied in various sectors, including automotive (Andrade et al., 2015; Vinodh et al., 2016), production (Ehie & Sheu, 2005; Ateekh-ur-Rehman, 2012), tourism (Rauch et al., 2016; Farrington et al., 2018), service (Comm & Mathaisel, 2003; Antony, 2004; Fisher et al., 2011), defense (Tatham & Worrell, 2010; Hawkins et al., 2015), textiles (Islam et al., 2013; Brahmadeep, 2014), agriculture (Dora et al., 2015; Melin & Barth, 2018), electronics (Chan & Spedding, 2003; Jeyaraman & Teo, 2010), construction (Freire & Alarcon, 2002; Ko & Kuo, 2015) and software development (Bubevski, 2016). Additionally, there are studies conducted using the Arena simulation program, which is also utilized in this research. These studies include traffic simulation (Kamrani et al., 2014), analysis of existing workflows in pharmacies (Alhaag et al., 2015), simulation models for student restaurants (Ghaleb et al., 2015), supply chain optimization (Vamanan et al., 2004), job scheduling problems (Nawara & Hassanein, 2013), open-pit mining transportation systems (Hashemi & Sattarvand, 2014), improvements in hold baggage security screening (AlKheder et al., 2020), production line layout optimization (Mohd Said & Ismail, 2014), evaluation of yogurt production lines (Mohammed Hasan et al., 2019), healthcare appointment system (Aliyu et al., 2015). Table 1 summarize the process improvement studies in the healthcare sector that have utilized lean and/or other tools.

Table 1

Literature of Process Improvement Studies in Healthcare using Lean and/or other Tools

Author	Lean or other tools	Department	Improvement
Womack et al. (2005)	VSM, Kaizen	Hospital	Business processes
Jimmerson et al. (2005)	VSM	Community Medical Center	Business processes
Bahensky et al. (2005)	Six Sigma, Kaizen	BT unit	BT processes
King et al. (2006)	VSM, Business process mapping	Emergency department	Waiting and time spent in the system
Lummus et al. (2006)	VSM	Medical Center	Waiting time
Kim et al. (2007)	VSM, Single Piece Flow	Hospital	Patient care process
Ben-Tovim et al. (2008)	Business process mapping	Hospital	Clinical process design
Chassin (2008)	Six Sigma	Medical Center	Patient care and business processes
Bisgaard and Does (2008)	Lean Six Sigma	Hospital	Cost and quality

(continued)

Author	Lean or other tools	Department	Improvement
Persona et al. (2008)	JIT, KANBAN	Hospital	Inventory management
Dickson et al. (2009)	Kaizen	Emergency department	Patient care process
Naraghi and Ravipati (2009)	Simulation, VSM, 5S	Emergency department	Service delivery
Snyder and McDermott (2009)	Lean training module	Hospital	Material supply time
Rexhepi and Shrestha (2011)	Kanban, 5S, VSM	Rheumatology Unit	Employee performance and waste areas
Laganga (2011)	Metrics and indicators	Hospital	Outpatient services
Mandahawi et al. (2011)	Six Sigma	Ophthalmology unit	Time spent in the system
Yeh (2011)	Lean Six Sigma, VSM	Hospital	Acute myocardial infarction treatment process
Papadopoulos (2011)	Continuous improvement	Pathology unit	Clinical decision and patient care processes
Mohammadi and Eneyo (2012)	TOC, Simulation	Radiotherapy	Patient flow
Lama et al. (2013)	Altı Sigma	Hospital	Delay in outpatient clinic and consultations before anesthesia
Toussaint and Berry (2013)	VSM	Children's hospital	Value-added and non-value-added activities
Ryan et al. (2013)	VSM, TOC	Emergency department	Bottlenecks
Mannon (2014)	Continuous improvement	Hospital	Quality of service
Amonge (2015)	TOC	Emergency department	Backlog of patients in emergency department, delay in making dispositions
Doğan and Unutulmaz (2016)	VSM, simulation	Physical therapy and rehabilitation unit	Waste and business processes
Aguilar-Escobar et al. (2016)	TOC	Clinical record logistics system	Clinical record processes
Alkinaidri and Alsulami (2018)	Lean Six Sigma	Medical Center	Dispatch system
Gege (2018)	Simulation	Emergency department	Length of stay in the hospital, resource allocation.
Grida and Zeid (2019)	Simulation, TOC	Operating room	Waiting time and resource utilization
Toda and Ginj (2019)	Gemba, 5S, Kanban	Pharmacy	Supply and workflow
Bauer et al. (2019)	TOC	Emergency department	Quality of service delivery
Batubara et al. (2020)	VSM, Simulation	Hospital	Value-added and non-value-added activities
Sunder M et al. (2020)	Lean six sigma	Mobile hospital	Improving patients' satisfaction
Ricciardi et al. (2020)	Lean six sigma	Orthopedics and traumatology unit	Implementation of fast track surgery
Le et al. (2022)	VSM	Emergency department	Hospital waiting times
Balkhi et al. (2022)	Just-in-time approach	Inventory management	Supply chain
El Jaouhari et al. (2022)	Lean thinking	Supply chain management	Lean supply chain management

As in other sectors, lean tools are increasingly utilized in process improvement studies within the healthcare sector. In the healthcare sector, various studies have applied lean tools to various areas, such as clinical process design, medical testing, emergency services, inventory management, appointment scheduling, hospital process design, medical record management, referral systems and supply chain management. The present study was conducted in the internal medicine department of an education and research hospital, which provides comprehensive healthcare services. This study differs from existing studies in several aspects. First, it focuses on the internal medicine department, where patient flow is particularly intensive. Second, the study examines the hospitalization process, which involves a range of procedures and patient interactions. Given the complexity of hospitalization, many unnecessary steps emerge, highlighting the need for a lean patient flow. In addition, to the best of our knowledge, no other study has integrated VSM, TOC, and simulation methods together in healthcare process improvement.

METHODOLOGY

Data Analysis and Procedure

Education and research hospitals are healthcare institutions with high patient volumes and complex business processes. Therefore, process improvements in these healthcare institutions are important for ensuring effective and quality healthcare delivery. For this study, the internal medicine department of an education and research hospital, which handles the highest patient flow, was selected as the focus of the study. This study utilized VSM, TOC, and simulation methods to analyze the internal medicine department. Data for the study were obtained from six months of hospital records. During the 118 days of the study period, a total of 41,101 patients visited the outpatient clinic, 777 patients being treated in the clinic. On average, 348 patients visited the outpatient clinic daily. All analyses were based on these data. The first step was to use VSM and TOC methods to map the current patient flow in the internal medicine department. The process began by selecting the service family, with the internal medicine service chosen for this purpose. Then, a CSM showing the door-to-door patient flow was drawn. Two distinct patient groups—those with social security and those patients without social security—were identified, leading to the creation of two separate current state maps (Appendix A and Appendix B). These maps helped identify waste and constraints in the existing process. Lean flow improvements were proposed through FSMs, which were developed for each patient group and presented in Appendix C and Appendix D.

Next, the TOC method was used to identify and eliminate constraints within the hospitalization process, as presented in the current state map. The Current Reality Tree (CRT), which is part of the TOC Thinking Processes, was used to uncover the root causes and problem areas underlying the constraints. Based on this analysis, improvement steps were proposed. These steps were incorporated into a lean model for the future state, which was then simulated using the Arena V14 simulation software. For this purpose, two different scenarios were created to model the proposed improvements. The details of these scenarios and their results are discussed in the results section.

RESULTS

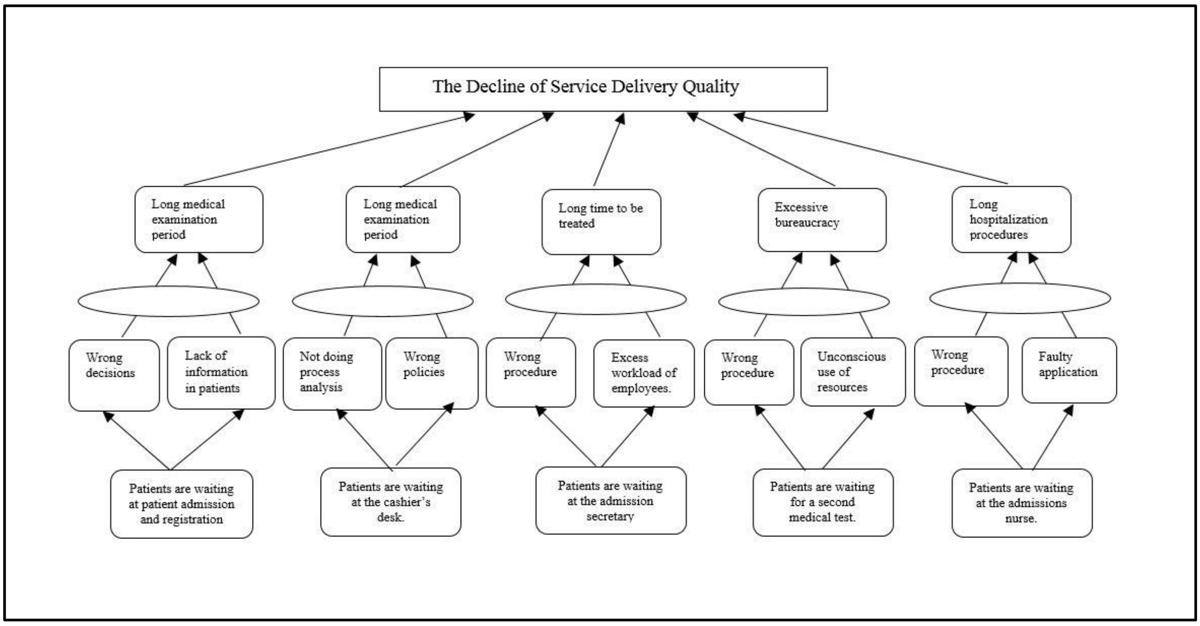
The VSM and TOC Analysis of Patient Flow in the Internal Medicine Department

Two distinct current state maps (CSMs) were developed and presented in Appendix A and Appendix B. Appendix A shows the CSM for patients with social security, while Appendix B illustrates the CSM for patients without social security. These maps contain time data, detailing the steps and duration of each stage in the patient flow process. For patients with social security, the hospitalization process consists of nine steps. The steps are as follows: Arrival at the hospital, patient admission and registration, polyclinic visit, medical tests, polyclinic visit (follow-up), admission secretary, medical tests (follow-up), admission nurse and assignment to a sick room. Using the CSM, the total length of stay in the system, as well as value-added and/or non-value-added times from the patient's perspective, were calculated. The length of stay in the system ranged from a minimum of 88 minutes to a maximum of 36,607 minutes. The minimum and maximum values for NVAT varied between 75 and 36,561 minutes, while value added time ranged from 13 to 46 minutes. For patients without social security, the hospitalization process involves ten steps. The steps are as follows: Arrival at the hospital, patient admission and registration, payment at the cashier's desk, polyclinic, medical tests, polyclinic visit (follow-up), admission secretary, medical tests (follow-up), admission nurse and assignment to a sick room. The length of stay for patients without social security was calculated to be between a minimum of 92 minutes and a maximum of 36,611 minutes. NVAT ranged from 79 to 36,565 minutes, while value-added time ranged from 13 to 46 minutes.

After mapping the patient flows, the TOC was applied to identify and address the root causes and problematic areas that affect the flow. The CRT, a key tool within the TOC thinking processes, was used to improve the process. Figure 1 shows the CRT, highlighting the identified problematic areas and their root causes.

Figure 1

Current Reality Tree



Waste and constraints in the patient flow were identified using CSM and CRT. To enhance the quality of service provided to patients, several improvement steps were proposed. These steps were incorporated into the FSMs for two different patient groups (patients with social security and patients without social security) were drawn using a different FSM. The FSMs are presented in Appendix C and Appendix D. For patients with social security, the current process involved nine steps. With the FSM improvements shown in Appendix C, this flow was streamlined to seven steps. The first improvement was applied in the patient admission and registration unit. This unit experienced significant patient waiting times. The first improvement aimed to reduce these delays. The second improvement targeted process efficiency in the area of admissions secretary and admissions nurse. As a result of these improvements, the total length of stay in the system was reduced from a minimum of 59 minutes to a maximum of 20,738 minutes. NVAT decreased to a minimum of 44 minutes and a maximum of 20,657 minutes. Value-added time increased, ranging from a minimum of 15 minutes to a maximum of 81 minutes.

For patients without social security, the current hospitalization process consisted of ten steps. By implementing the FSM adjustments detailed in Appendix D, the patient flow was reduced to eight steps. In addition to the improvements shown in Appendix C, further enhancements were made to the cashier's desk process. As a result, the length of stay in the system for patients without social security was also reduced, now ranging from a minimum of 59 minutes to a maximum of 20,738 minutes. NVAT decreased to a minimum of 44 minutes and a maximum of 20,657 minutes, while value-added time ranged from a minimum of 15 minutes to a maximum of 81 minutes.

Simulation in the Internal Medicine Department

The patient flow within the internal medicine department was modelled using a simulation approach. The current patient flow, as depicted in the current state maps, was translated into a simulation model. Two different scenarios were developed to assess the impact of proposed improvements on the system based on future state maps. The patient flows in the internal medicine department were modelled using the Rockwell Arena Simulation V14.0 software.

Current and Future State Simulation Models

The simulation included two distinct patient groups (patients with social security and patients without social security), combined into a single model for the current state simulation. The patient arrival rate was set according to the hourly patient inflow during regular working hours. Data from the hospital's statistics department were analyzed using the Input Analyzer tool and then integrated into the model. Table 2 shows the statistical distributions of process times used in the current simulation model.

Table 2

Statistical Distribution of Processes

Process	Distribution	Value (minute)
Arrival of patient	Normal	NORM (43.9, 9.41)
Patient admission & registration	Triangular	TRIA (0.5, 2.15, 3.5)
Cashier's desk	Normal	NORM (1.83, 0.637)
Polyclinic 1	Normal	NORM (5.13, 0.249)
Blood test unit	Triangular	TRIA (1.39, 1.79, 2.71)
USG	Uniform	UNIF (7.15, 11)
X-ray	Triangular	TRIA (8.16, 8.98, 9.84)
MRI	Triangular	TRIA (33, 34.1, 35.6)
Polyclinic 2	Triangular	TRIA (5.05, 5.95, 6.85)
Admission secretary	Triangular	TRIA (6, 6.1, 6.55)
Blood test unit 2	Triangular	TRIA(1.39, 1.79, 2.71)
Other medical test(s)	Uniform	UNIF (34.6, 36)
Admission nurse	Uniform	UNIF (6.84, 7.32)

Based on the collected data, the process times used in the current simulation model were calculated in minutes. It was determined that the process times for patient admission and registration, blood test unit, X-ray, MRI, polyclinic 2, admissions secretary, blood test unit 2 process times followed a triangular distribution. The process times for the Cashier's desk and polyclinic 1 conformed to a normal distribution, while the process times for USG, other medical tests and the admission nurse process were best represented by a uniform distribution. Table 3 shows the resources used in the current simulation model for patient flow within the internal medicine department. The values in Table 3 were obtained from the statistical department of the hospital.

Table 3

Resources

Unit	Human Research	Device
Patient admission & registration	1 Secretary	1 QMatic
Polyclinic 1	5 Doctors, 5 Secretaries	-
Blood test unit	4 Technicians	-
USG	4 Technicians	4 Ultrasonography
X-ray	4 Technicians	4 X-ray machines
MRI	1 Technician	1 MRI machine
Polyclinic 2	5 Doctors, 5 Secretaries	-
Admission secretary	2 Secretaries	-
Blood test unit 2	4 Technicians	1 machine
Other medical test(s)	1 Technician	-
Admission nurse	5 Night nurses, 5 Nurses, 2 Responsible nurses	-
Sickroom	5 Night nurses, 5 Nurses, 2 Responsible nurses, 5 Doctors, 2 Secretaries	47 sickbeds
Cashier’s desk	1 Cashier	-

The model was verified to ensure it functioned as intended. At this stage, the "Run-Check Model" feature in the Arena software was used. The verification process of the system was confirmed with the message "No errors or warnings in model". The model was then validated to assess whether the model outputs aligned with those of the actual system. Initially, the data's compatibility with a normal distribution was assessed during the validation process. Once the normal distribution of the data sets was established, a paired sample t-test was conducted to check for any significant differences between the two groups. The results showed no significant difference according to the paired t-test ($t(11) = 0.702$, $p = 0.497 > 0.05$ at confidence interval of 95 percent, and a significance level of $\alpha = 0.05$). Thus, the model was validated successfully.

Following the verification and validation of the current state model, future state simulation models incorporating proposed improvements were developed. Two different scenarios were designed for the future state simulation model. The first scenario focused on minimizing non-value-added steps for patients, while the second scenario presented a leaner patient flow. In developing these scenarios, the future state maps and the current reality tree were used as guiding tools.

Analysis of Simulation Results

The analysis of simulation results was conducted by comparing the outputs of the current state simulation model with those of the future state simulation models. Key performance metrics used for comparison included transfer time (TT), non-value-added time (NVAT), and length of stay (LoS). Both the current and future state simulation models were run with 30 replications each. The results showed statistically significant differences between the outputs of the current and the future simulation models at a significant level of $\alpha = 0.05$. Based on these results, both proposed scenarios led to reductions in LoS and NVAT times.

Table 4 presents the comparison results of the mean values between the current state model and the two different scenarios designed for the future state.

Table 4

Comparison of Simulation Models in Terms of Mean Values

Comparison metrics (minute)	Simulation model			Improvement rate	
	Current simulation	Scenario 1	Scenario 2	Scenario 1	Scenario 2
NVAT	530	298 ↓	147 ↓	44 %↓	72 %↓
LoS	20469	20162 ↓	17847 ↓	1 %↓	12 %↓
TT	26	3 ↓	2 ↓	88 %↓	92 %↓

It can be seen from Table 4 that the mean NVAT was reduced by 44 percent in the first proposed scenario and by 72 percent in the second proposed scenario. The LoS for patients showed a marginal improvement of 1 percent with the first model, but a significant reduction of 12 percent with the second model. The TT decreased substantially, by 88 percent in the first scenario and by 92 percent in the second scenario. Additionally, the current simulation model and the proposed scenarios were compared based on the number of patients whose medical tests were completed. The comparison results are shown in Table 5.

Table 5

Comparison of Simulation Models Based on the Number of Patients Completing Medical Tests

The number of patients	Simulation model			Improvement rate	
	Current simulation	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Blood test unit	12237	15475 ↑	17567 ↑	26 % ↑	43 % ↑
MRI scan	273	396 ↑	469 ↑	45 % ↑	71 % ↑
USG scan	3241	4224 ↑	4767 ↑	30 % ↑	47 % ↑
X-ray scan	1303	1679 ↑	1899 ↑	28 %↑	45 % ↑

As shown in Table 5, implementing the first proposed scenario led to a 26 percent increase in the number of patients who completed blood tests. Additionally, the number of patients who underwent MRI, USG and X-ray scans increased by 45 percent, 30 percent and 28 percent, respectively. With the second proposed scenario, the improvements were even more pronounced. The number of patients who completed blood tests increased by 43 percent, while the number of patients who underwent MRI, USG and X-ray scans increased by 71 percent, 47 percent and 45 percent, respectively.

DISCUSSIONS AND IMPLICATIONS

Healthcare services are demand driven services, where the demand is uncertain and mistakes cannot be tolerated. Due to the unpredictable time and location of the demand for healthcare services, it is crucial to that these services should be provided with appropriate quality, cost efficiency and suitable conditions. Any activity that does not add value to the patient during service delivery is considered waste and efforts should be made to minimize or eliminate all types of wastes. Using lean tools to eliminate waste, can bring numerous benefits to healthcare institutions, including reducing costs, increasing the number of treated patients, lowering inventory levels, and improving the working environment.

In order to provide better healthcare to patients, it is essential to eliminate all non-value-added activities throughout the service delivery process. Using VSM helps to outline the entire patient flow, from arrival to discharge, and quantifies the value-added and non-value-added times experienced by the patients. Every patient seeking treatment at a healthcare facility encounters at least one constraint during the process. Effectively managing these constraints, which hinder efficient health service delivery and disrupt patient flow, is critical for healthcare institutions. TOC helps identify constraints arising from processes and focuses on their elimination. Once the constraints are determined, the following step is their elimination. In this context, simulation methods serve as a valuable tool to represent the real system, enabling healthcare providers to understand the existing processes and evaluate various improvement suggestions.

This study examined how lean thinking can be applied to improve the hospitalization process in the internal medicine department, the area with the highest patient flow within the institution. The first step was to identify non-value-added steps from the patients' perspective. For patients, value is defined as receiving treatment services that are efficient, reliable and affordable. Consequently, any step that does not contribute to the treatment of patients is termed as waste. VSM was used to identify these wasteful steps, while FSM was used to establish a continuous flow, minimizing waiting time and delays in the healthcare service delivery process. The constraints and problematic areas disrupting patient flow were determined and resolved using CRT of TOC. The simulation method was then applied to avoid the risk associated with trial and error decision-making and to evaluate alternative strategies by modeling the current system.

The basis of lean thinking is to ensure a continuous flow. Achieving a smooth flow requires the elimination of all unnecessary movements, waiting times, excess inventory and non-value-added activities. For this purpose, simulation models were created based on two distinct scenarios designed to support continuous patient flow. It was observed that implementing the proposed recommendations significantly reduced non-value-added times during the hospitalization process in the internal medicine. In the first scenario, simulation a model was developed to minimize non-value-added steps for patients, while the second scenario presented a simulation model with an even leaner flow.

Various studies using process improvement tools such as value stream mapping, Six Sigma, theory of constraints, kaizen, and simulation have shown significant improvements across numerous aspects of the healthcare process. For instance, Jimmerson et al. (2005) successfully reduced the time from medication order to treatment from 4 hours to 12 minutes. Kim et al (2007) decreased the number of steps needed to initiate treatment from 27 to 16. Chassin (2008) reduced the bed turnover rate by 90 minutes and lowered errors in test results by 81 percent. Snyder and McDermott (2009) reduced the wait time for emergency department patients transferred to floors by 10 percent. Mandahawi et al. (2011) managed to reduce patient turnover time from 48 minutes to 20 minutes. Grida and Zeid (2019) achieved an 88 percent reduction in patient waiting time. More recently, Le et al. (2022) reported reductions in pre-operative test results by 33.3 percent, vascular intervention times by 10.4 percent, patient admissions to other hospital departments by 49.5 percent. This study was carried out in the internal medicine department, which experiences the highest patient demand. It not only led to improvements in transfer time, waiting time and overall length of stay but also provided insights into diagnostic and medical testing processes.

In terms of theoretical contributions, this study is the first to integrate value stream mapping, theory of constraints and simulation methods into a unified framework. With this unique approach, this study is expected to serve as a valuable reference for future research. Additionally, the findings of this study are intended to guide healthcare managers and researchers in this field. By transforming healthcare institutions into lean organizations, service quality can be enhanced through a continuous patient flow, ultimately enabling financial benefits for the institutions.

CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH DIRECTIONS

Utilizing lean tools to eliminate waste in healthcare processes can lead to reduced costs, improved employee motivation, increased in the number of patients receiving treatment and a better working environment. By transforming healthcare institutions into lean organizations, service quality can be enhanced through a continuous patient flow. Any waste occurring during healthcare service delivery, not only increases cost but also negatively affects patient treatment. From the patient’s perspective, value is defined as a treatment service offered efficiently, reliably and affordably. Therefore, all steps that do not contribute to the patient’s treatment process should be eliminated. Patients visiting healthcare institutions often encounter at least one constraint. Effectively managing these constraints, which hinder efficient healthcare service delivery and disrupt patient flow is important of improving overall healthcare quality. Providing better healthcare requires the elimination of all non-value- added activities.

This study shows how lean thinking can be applied to improve the hospitalization process in the internal medicine department, which experiences the highest patient demand. Implementing lean practices can increase the number of patients treated and reduce waiting times. However, like other studies, this study has some limitations. This study focused primarily on time-based comparison metrics. Future studies could adopt cost-oriented comparison criteria, focusing on specific medical diagnosis groups and length of hospitalization. In addition, process improvement studies encompassing all hospital departments could be conducted to provide a holistic view of hospital operations. In addition, using annual data instead of monthly data would provide more comprehensive results. Since the number of outpatients and inpatients varies seasonally, long-term data analysis is important for accurately representing the system.

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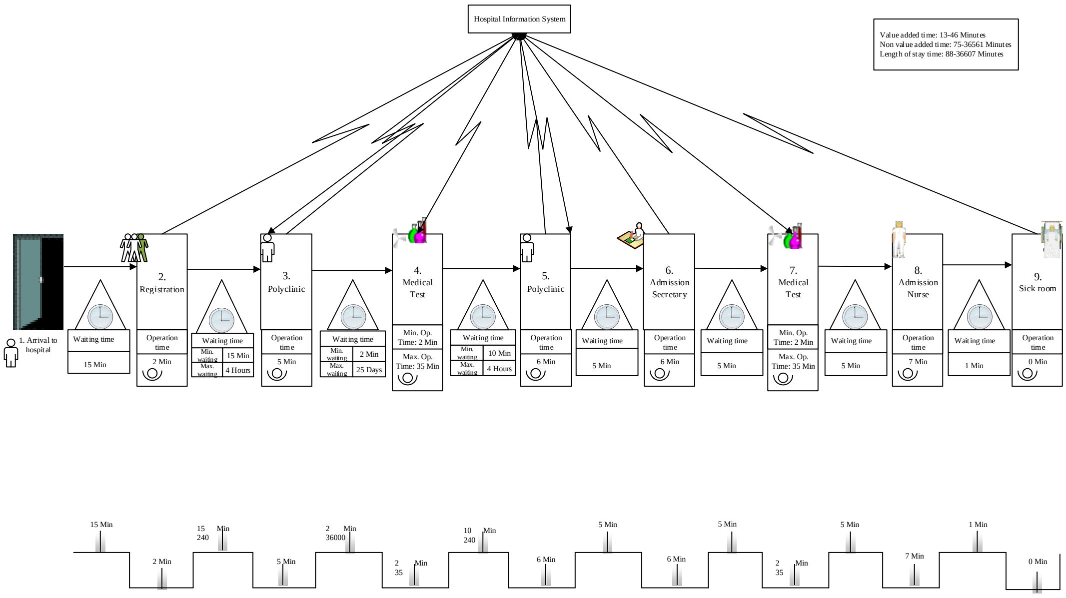
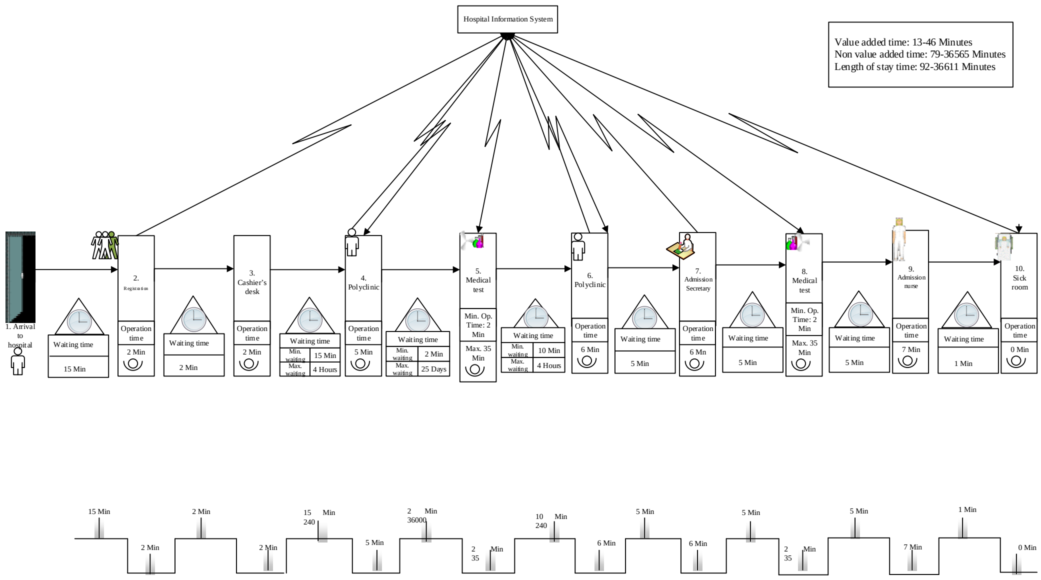
APPENDIX A

Current state map of internal medicine patients with social security



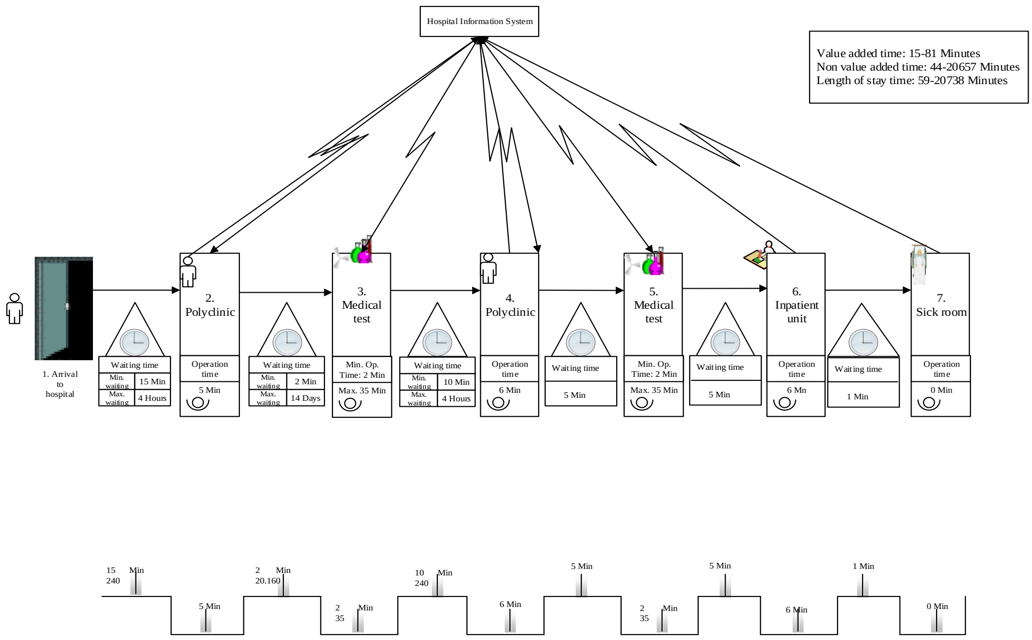
APPENDIX B

Current state map of internal medicine patients without social security



APPENDIX C

Future state map of internal medicine patients with social security



APPENDIX D

Future state map of internal medicine patients without social security