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Application of VSM for improving the medical processes - case study

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Abstract. Lean Manufacturing has been used in many types of organizations, including healthcare. In the healthcare area, lean healthcare is a management philosophy to develop a hospital culture characterized by increased patient, and other stakeholder, satisfaction through continuous improvements. The starting point for improving activities in the healthcare is identification of the problems and wastes in the processes. In this context VSM is a helpful tool. That why the purpose of this paper is to present the possibility of application the VSM for improving the selected process in the healthcare. Thanks to the application of this method, the necessary information on the sources of losses in the analyzed process was obtained.

Keywords: Lean Healthcare, Value stream mapping, process improvement

1 Introduction

Global industry motivates companies to seek and implement more competitive production system. Many of them are implementing or planning to implement Lean Manufacturing (LM). This philosophy, developed in the 1990s, is based on the Toyota Production System (TPS) [1-3] and is mainly used in industry to increase the performance and efficiency of processes. Its assumptions are based on the paradigm of creating value from the customer's point of view and attempts to minimize and eliminate all kinds of waste in the processes. LM has been used in many types of organizations, including healthcare [4-7]. In the health sector, it is referred to as Lean Healthcare (LH), and in healthcare hospitals - Lean Hospitals (LHo). Lean Healthcare is based on five fundamental principles formulated by [8]. In the healthcare area, lean health care is a management philosophy to develop a hospital culture characterized by increased patient, and other stakeholder, satisfaction through continuous improvements, in which all employees (managers, doctors, nurses, laboratory people, technicians, office people etc.) actively participate in identifying and reducing non-value added activities (waste) [9].

The methods and tools of LH (or LHo) are, e.g.: 5Why, 5S, visual control and kanban, Poka Yoke, value stream mapping (VSM), work standardization [10,11]. The

result of their application in healthcare is the improvement of work organization, minimizing the time lost, for example, due to improperly identified medical documentation, medical materials and tools, and long waiting times [12]. Value stream mapping helps to minimize or eliminate unnecessary activities, which improving the quality and safety of patient service, as well as shortening the treatment time.

In this context VSM in healthcare is a potential, helpful tool to reduce patient time in the hospital and traditional management costs [13,14]. The major benefits of VSM over other techniques are: (1) VSM helps visualize the process using iconic representation; (2) VSM helps identify the sources of waste in the process; (3) VSM shows the linkage between information flow and material flow; and (4) VSM helps form the basis of an implementation plan [15, 16]. That why the main goal of the paper is to present the possibility of use VSM to identify and analyze sources of waste in the process of patient rehabilitation in the healthcare. Given the purpose above, the paper is organized as follows: in Section 2 the work methodology is presented. Then, in Section 3 the results of VSM application for the selected processes are shown. Finally, the conclusions and direction of the future research are presented.

2 Research methodology

The value stream mapping (VSM) method has been used to implement lean concepts in order to enhance services in rehabilitation department in the hospital. The research methodology included the following stages: (1) Selection of the area for analysis. (2) Collection of data from the process. (3) Development of the current state map. (4) Problem identification and analysis. (5) A proposal for improvement activities. (6) Development of the future state map. (7) Evaluation of the effectiveness of the proposed improvements. The goal of the Current State -VSM was to identify the causes of problems and wastage in order to propose solutions to decrease the lead-time of the particular service. Based on the aforementioned analysis and proposed improvements a Future State -VSM has been proposed. The activities of the selected process have been analyzed to identify: lead time (LT), value-added (VA) time, non-value-added (NVA) time and necessary-non-value-added (NNVA) time. The formulas presented in [17], have been used to perform necessary calculations:

$$LT = \sum_{i=1}^n A_i \quad (1)$$

where:

A_i – time of the i^{th} activity, $i = 1, \dots, n$;

n – number of activities.

$$VA = \sum_{i=1}^m A_{VA i} \quad (2)$$

where:

$A_{VA i}$ – time of the i^{th} value-added activity, $i = 1, \dots, m$;

m – number of value-added activities.

$$NVA = \sum_{i=1}^m A_{NVA i} \quad (3)$$

where:

A_{VAi} – time of the i^{th} value-added activity, $i = 1, \dots, m$,

m – number of value-added activities.

$$NNVA = \sum_{i=1}^p A_{NNVAi} \quad (4)$$

where:

A_{NNVAi} – time of the i^{th} necessary-non-value-added activity, $i = 1, \dots, p$,

i - number of necessary-non-value-added activities.

3 Results

3.1 Process description

The subject of the analysis was the daytime rehabilitation process of patients in a selected hospital ward. The aim of the first stage was to identify "patient families". The medical procedures used in the unit (stages of treatment) and the illnesses experienced by the patient were used for identification. The Department of Therapeutic Rehabilitation admits patients after stroke (AS), after heart attack (AHA), with a shoulder injury (SHI), after breaking a leg (ABL) and arm (ABA) as well as with a spine injury (SPI). After analyzing the stages of treatment and the diseases of patients who go through the same stages of treatment, the families of patients can be identified (Table 1).

Table 1. Identified "patient families"

Treatment stage	Patient					
	AS	AHA	SHI	SPI	ABL	ABA
Self -assisted exercises	X	X		X		
Balance exercises	X	X	X		X	X
Resistance exercises			X		X	X
Upright standing	X	X	X		X	
Restoring precision of movements	X	X	X		X	X
Hospitalization	X	X				
Isometric exercises	X	X	X	X	X	X
Mobilization			X	X	X	X
Active exercises			X	X	X	X

Based on the similarities and treatment stages, two main groups of patients can be identified. The first one (green colour) is a group of patients after AS and AHA treatment steps are the same. The second family (red colour) consists of patients who regularly come to the Ward and try to achieve full fitness after breaking the lower and upper limbs. Value stream mapping was performed for the entire rehabilitation process of patients in group 1.

3.2 Current state analysis - current state map (CS-VSM)

The data for the process analysis was collected by analyzing the day of the selected patient's stay at the Therapeutic Rehabilitation Department. The patient spends 24 hours in the ward, but the day of his activity lasts about 10 hours. Each day of the patient looks similar in terms of the exercises performed. The individual steps of the rehabilitation process are as follows [18]:

Stage 1. Visit to the general practitioner. The patient reports to his general practitioner. Describing his ailments, he receives a referral to a specialist doctor in order to perform the necessary tests.

Stage 2. Waiting in line. Waiting for the patient to see a specialist.

Stage 3. Visit to a specialist doctor. In conversation with the patient, the doctor conducts a medical interview in order to select the appropriate scope of tests.

Stage 4. Waiting in line. Waiting for the patient to perform the test.

Stage 5. Performing the test. The responsible person performs tests on the patient according to the doctor's instructions. After the test, he performs its description and orders to return to the specialist doctor.

Stage 6. Waiting in line. Waiting for the patient to see a specialist.

Stage 7. Another visit to the specialist doctor. On the basis of the performed examination, its description and an additional conversation with the patient, the doctor gives the final diagnosis to the patient and directs him to the hospital.

Stage 8. Waiting. The patient waits for a place to become available in the Rehabilitation Department.

Stage 9. Admission to hospital. The patient goes with the referral and full health documentation to the Admission Room. The patient is admitted to the hospital and referred to the ward.

Stage 10. Admission to the ward. At the Rehabilitation Department, the doctor on duty checks the patient's health records, establishing a plan of appropriate treatments and exercises.

Stage 11. Waiting. The patient is expected to wait for the next working day again. On the day of admission to the ward, he does not perform any procedures or exercises.

Stage 12. Performing balance exercises. The patient, together with the physiotherapist, goes to the rehabilitation rooms, where he performs a series of balance exercises.

Stage 13. Performing resistance exercises. Immediately after the balance exercises, the patient switches to resistance exercises.

Stage 14. Waiting. After prolonged physical exertion, the patient needs rest before carrying out any further exercises.

Stage 15. Upright standing. Standing upright is the most important exercise for this group of patients. They are designed to restore the smoothness of movements.

Step 16. Waiting. Bad work organization of employees means that the patient has to wait for the next stage of exercise.

Stage 17. Performing exercises to restore precision of movements. Performing exercises that restore the precision of movements by circling the shoulders, raising the hands, bending the elbows, rolling objects on the ground and grasping objects.

Stage 18. Waiting. Expectation of the patient, due to the lack of availability of exercise equipment at the moment.

Stage 19. Performing isometric exercises. The patient goes to the strengthening exercise rooms, where he performs a series of exercises that strengthen the spine, abdominal muscles, back muscles and limbs.

Stage 20. Mobilization. Immediately after the isometric exercises, the patient starts mobilization exercises.

Stage 21. Waiting. Waiting for a free exercise room.

Stage 22. Active exercises. At the end of the day, the patient performs exercises to improve muscular endurance and increase the efficiency of the circulatory and respiratory system.

Stage 23. Decision to continue the patient's hospitalization. Physiotherapists, together with the doctor on duty, assess the patient's health condition and its progress in treatment. Based on observation and discussion, they make a decision regarding his further hospitalization.

Stage 24. Waiting. The patient is waiting for the next day. On the next day, the patient repeats the early stages of treatment (12-23).

Stage 25. Waiting in queue. The patient is waiting in a queue for a check-up with a specialist doctor.

Stage 26. Follow-up visit with a specialist doctor. After hospitalization, the patient goes for a follow-up visit. The doctor re-assesses the patient's health, completes the medical documentation and issues the patient an discharge from the hospital.

Stage 27. Release from hospital. The doctor on duty completes the formalities related to the patient's release from the hospital and gives consent to leave the hospital.

Fig. 1 shows a part of a current state value stream map (CS-VSM) of the selected process. In the process, waiting time appears as well as many problems.

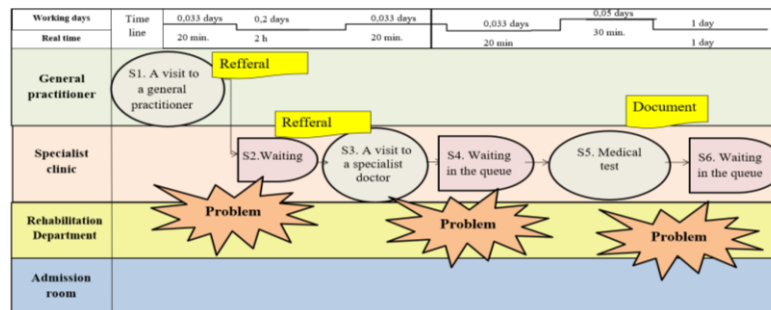


Fig. 1. The current state value stream map (CS-VSM) - a part

3.3 Problem identification and proposals of improvements

The analysis of the current state map (CS-VSM) allowed for the identification of problems occurring in the process. For the identified problems, improvement actions were proposed (Table 2). The main goal of the proposed activities is to improve the analyzed rehabilitation process, which will allow to decrease the lead time (LT).

Table 2. Problems and proposal for improvements - selected problems

Name and description of the problem	Proposal of improvements
<i>Problem 1: Incorrect patient registration system</i>	
The patient arrives at the clinic several hours before the doctor arrives on duty to be sure that that it will be accepted. He registers and waits for the doctor to come to the office.	Creation of a website or application, thanks to which each patient could register with a doctor at a suitable date and time.
<i>Problem 2. Long admission time to the hospital</i>	
The patient waits for admission about 60 days. This is due to the limits in accordance with the agreement signed with the Polish National Health Fund (NHF) and the availability of places in the hospital.	Increasing the number of places in the hospital and analyzing the possibility of increasing admission limits.
<i>Problem 3: One person dealing with carrying out and describing the test</i>	
The person responsible for carrying out the tests is on duty alone, which extends the time of carrying out the test and describing it.	Reorganization of employees' work. This action solves problem 3 and contributes to the deletion of steps 4, 6 and 7 of the process.
<i>Problem 4: Lack of a person responsible for coordinating the activities of the admission room staff</i>	
There is no person responsible for supervising and coordinating the activities carried out by the staff of the admission room as part of the admission process. The consequence is poor organization of staff work and long process implementation time.	Choosing a team coordinator. From among all the admission room employee, one person should be selected who would coordinate the work of employees and supervise the process of entering data into the database in order to improve this activity.
<i>Problem 5: Incomplete health records received from the patient</i>	
The patient who comes to the ward does not have complete health records. This prevents the physician from determining the type of treatments and increases the time required to create a framework exercise plan.	Developing a check list with the list of required documents and making it available to the patient before coming to the ward.

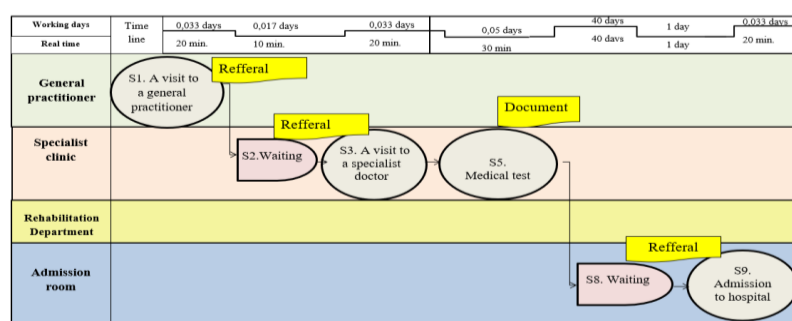
3.4 Development of the future state map (FS-VSM)

By solving the analyzed problems and eliminating mainly the waiting times, it will be possible to decrease the duration time of some activities from CS-VSM and finally the lead time (LT) (Table 3). Additionally, it will be possible to eliminate some NAV.

Table 3. The duration time of activities - CS-VSM and FS-VSM

Stage	Value	CS-VSM	FS-VSM	Stage	Value	CS-VSM	FS-VSM
S1	AV	20min	20min	S15	AV	1h	5min
S2	NAV	12min	10min	S16	NAV	30min	45min
S3	AV	20min	20min	S17	AV	45min	45min
S4	NAV	20min	0	S18	NAV	1h	0
S5	AV	30min	30min	S19	AV	45min	45min
S6	NAV	1 day	0	S20	AV	30min	30min
S7	NAV	10min	0	S21	NAV	10min	0min
S8	NAV	60 days	40 days	S22	AV	45min	45min
S9	AV	30min	20min	S23	NNVA	30min	2h
S10	AV	45min	20min	S24	NAV	2h	0
S11	NAV	1 day	1 day	S25	NNVA	2h	30min
S12	AV	45min	45min	S26	AV	30min	20min
S13	AV	30min	30min	S27	NNVA	20min	5min
S14	NAV	1h	1h				

Fig. 2 shows a part of a future state value stream map (FS-VSM) of the selected process. In the process thanks to improvements the stages 4, 6 and 7 were removed, so are not included in the FS-VSM.

**Fig. 2.** The future state value stream map (FS-VSM) - a part

3.5 Assessment of the effectiveness of the implemented activities

Using the indicators from Table 1 and the data collected from the process with the support of VSM, the rehabilitation process performance have been analyzed.

Table 4 presents the comparison of VA, NVA, NNVA and LT in the CS-VSM and FS-VSM. It should be noted that the value of all indicators decreased. LT decreased about 35%.

Table 4. Comparison of VA, NVA, NNVA and LT - CS-VSM and FS-VSM

Indicator	CS-VSM	FS-VSM
AV	8h 58min	8h 40min
NAV	62 days 5h 22min	41days 2h 30min
NNAV	2h 50min	50min
LT	≈ 65 days	≈ 42 days

4 Conclusions

The aim of this article was to use VSM for analysis to identify and analyze sources of waste in the process of patient rehabilitation in the healthcare. Thanks to the application of the method, the necessary information on the sources of losses in the analyzed process was obtained. The use of VSM made it possible to identify areas of improvement not only for one process, but also for other services provided. Even partial of the proposed changes may contribute to increasing the efficiency and quality of the services provided. The proposed activities allow for the achievement of potential benefits in the form of shortening LT. However, one should bear in mind the potential difficulties and organizational and social limitations that may be related to the implementation of the proposed improvement activities. Before starting the implementation of changes, appropriate discussions and analyzes should be carried out in cooperation with the hospital management, the body authorized to supervise the activities of the institution. It should not be expected that the effects of the introduced changes will be visible immediately, as it is a long and complicated process.

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