ISSN: 0976-3104
SPECIAL ISSUE: Healthcare Systems Management

ARTICLE

PROCESS IMPROVEMENT IN A RADIOLOGY DEPARTMENT WITH VALUE STREAM MAPPING AND ITS LINKAGE TO INDUSTRY 4.0

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ABSTRACT

Background: *The current state of the hospitals' departments can be provided by some lean management tools. With the help of the value stream mapping, the big picture of a whole process can be seen. This picture shows every step that the patient will follow and it also tells about the cycle time for each service.* ***Methods:*** *The data storage system is very insufficient so that data are collected from hospital staff and by personal observations. A lean management tool, value stream mapping is used to see the general view of the radiology department with its problems at a glance. Data and the map is used as a guide to conduct a quality house to make a prioritization between the problems, to decide which one to solve firstly, of patients at the hospital.* ***Results:*** *Problems of the radiology department related to mammography and ultrasound and suggestions to these problems according to the industry 4.0 linkage.* ***Conclusions:*** *For current situation, new technological mammography and ultrasound devices are needed to increase the level of patient treatment at the same time and to decrease waiting times. The IoT will lead connecting every machine together that means sending results of a patient will be done simultaneously. Similar to the future state map, writing and giving a report to a patient will not take any time so that patient satisfaction will increase.*

KEY WORDS
Healthcare systems, lean thinking, process improvement, value stream mapping, industry 4.0.

Received: 29 June 2018
Accepted: 24 July 2018
Published: 12 Sept 2018

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INTRODUCTION

Today quality definition is totally turned out to satisfy customers on time. This goal can be reached by some calculations in a production line but it is more difficult for a service sector. Especially in healthcare systems, it is more important to give a high-quality service to the patients. When the human life is considered, it is vital to start the treatment quickly. Waiting is the biggest problem at the hospital, which increases the risk of exacerbation of the disease. Even at the beginning of the healthcare system, patients try to get appointment from the hospital and they wait for long time periods, sometimes for months, to see the doctor.

These kind of delays leads to the integration of lean management and healthcare systems. Lean management aims to eliminate actions which do not add any value to the process that are defined as "waste". Elimination of non-value-added steps, shortens the lead time of the process which means to reach customer more quickly. The current state of the hospitals' departments can be provided by some lean management tools. With the help of the value stream mapping, the big picture of a whole process can be seen. This picture shows every step that the patient will follow and it also tells about the cycle time for each service. If any of the service steps is not necessary, it is tried to be eliminated such as walking between too many doors, waiting for the reports, waiting for registration etc.

Non-value-added activities' elimination is not the only thing that should be considered. Patients' satisfaction is also important and it should be checked if they want anything according to the system and the hospital as a building. The way to convert customers' needs to real developments is to use "House of Quality" (HOQ) which is a tool for quality function deployment (QFD). Voice of customer leads to technical properties of the thing that can be either a product or a service, and new product / service development will be the result.

The needs of patients are very important to draw the future state map of the hospital's department. Both current state map and HOQ will help to conduct future state map of the value stream. In this study, data is taken from the article which gives details about the radiology department's current situation at Şişli Hamidiye Etfal Hospital in Istanbul, Turkey [1]. The radiology department is considered with its mammography and ultrasound units. The purpose of this paper is to improve the mammography and ultrasound screening processes to increase the healthcare system quality and patients' pleasantness while decreasing costs.

After the introduction part, lean management and lean in healthcare topics will be covered under literature review. In the third part, methodology will be explained and then current state of the radiology department will be mentioned. Industry 4.0 linkage of process improvement will be studied at the fifth part and finally a future state map will be shown before the conclusion part.

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IIOAB JOURNAL
ISSN: 0976-3104

LITERATURE REVIEW

Lean management

Lean Manufacturing, which is also named as "Toyota Production System (TPS)" was a new process-driven production system for the industry, founded by Japanese leaders [2]. The main aim of lean manufacturing is to get rid of the "waste" while increasing the quality of the product [3]. Waste types can be classified in eight different ways: producing more than the need, inventory, defects, waiting, transportation, extra motions, non-value-added activities and the unused human ability. These waste cost nearly 95% of the whole production cost which is mentioned by Taiichi Ohno who is one of the leaders of TPS [4]. Lean principles mainly aim to make a sustainable production line while eliminating non-value-added activities. This line has to work with customer orders which means a pull system [3].

In August 1997, a non-profit organization "Lean Enterprise Institute, Inc." was founded by James P. Womack. He aimed to explain lean thinking in accordance with the Toyota system which is being used by many different sectors spread wide [5]. The Lean Enterprise Institute website gives detailed information about lean principles which is summarized in [Fig. 1].

Fig. 1: Lean principles. (https://www.lean.org/WhatsLean/Principles.cfm, retrieved 05.03.2018).

Not only in manufacturing but also service industry uses lean principles in spite of application of mentioned ones are certainly different. The difference is that many service areas works with pull system, which means the customers' needs trigger the production of the service. If the system has problems in terms of the process, then waiting periods will be longer [6].

Lean in healthcare

In a production line, lean manufacturing aims to create a high-quality product and an on-time shipment to the customer. In Canada, these lean principles are concerned for healthcare systems because of the excess patient amount [7]. Recovery of the patient is the total of the value created in the medical service. For this reason, as mentioned for production line, also in healthcare sector, the process has to be customer-based, that means patient-based at a hospital [8].

In a healthcare system, to reach a "perfect" medical experience, delays, waiting times in a queue, unnecessary repeating actions, and false applications should be eliminated or at least minimized. When lean principles are adapted to health care systems to create value, some issues have to be considered such as patients, taxpayers and service providers' equality and the legal issues for costing while reaching the required pleasant level for patients. Even tough every process in a production line is known by its standards, in a service line especially at a hospital, patients' road is not clear due to different examination results. This uncertainty causes more complicated systems to be analyzed [9].

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IIOAB JOURNAL
ISSN: 0976-3104

Waste definition differs from sector to sector so that when health care systems are considered, mostly documentation causes “waste”. Also, the whole process flows and the hardware of the hospital can yield non-value-added activities [10].

MATERIALS AND METHODS

Value stream mapping

Implementing lean principles starts with the analysis of current situation to classify value added and non-value-added activities. Value stream mapping is one of the most efficient way to do this classification. The map shows the whole process of the production or service line with symbols. Its minimal structure is mainly related to “lean thinking”. The process drawn in the value stream map starts from the beginning that raw materials come from suppliers and ends at the shipping department. The expert which draws the map, follows both the production steps and information flow at a random time and captures that moment. This map is called “current state map” [11].

Current state map shows the bottlenecks on a one picture. With lean principles, these problems which are classified as non-value-added activities, should be eliminated or improved. After eliminating those “waste” improvement areas are shown in “future state map” [12].

Current State of the radiology department

The current state of the radiology department of Şişli Etfal Hospital, is visualized by the value stream map. This method captures a random moment to see the value added and non-value-added activities on a single picture. Cycle times of the related processes can be seen on the current state map [Fig.2].

The timeline shows both value added and non-value-added activities’ durations. Bottom lines between processes shows non-value-added activities, mostly waiting activity for the patient. The biggest bottleneck is waiting for the mammography appointment date, the report and the ultrasound appointment date. These durations are close to each other which is 3-4 days in average.

The value-added activities are only presents the steps to get the result from the doctor in the end. This time is totally 67.3 minutes, nearly 1 hour. But the whole process continues totally for 17367.95 minutes, nearly 12 days. This big difference is caused by the “waste” which decreases patients’ satisfaction. The house of quality will help to understand which problem to focus and improve firstly.

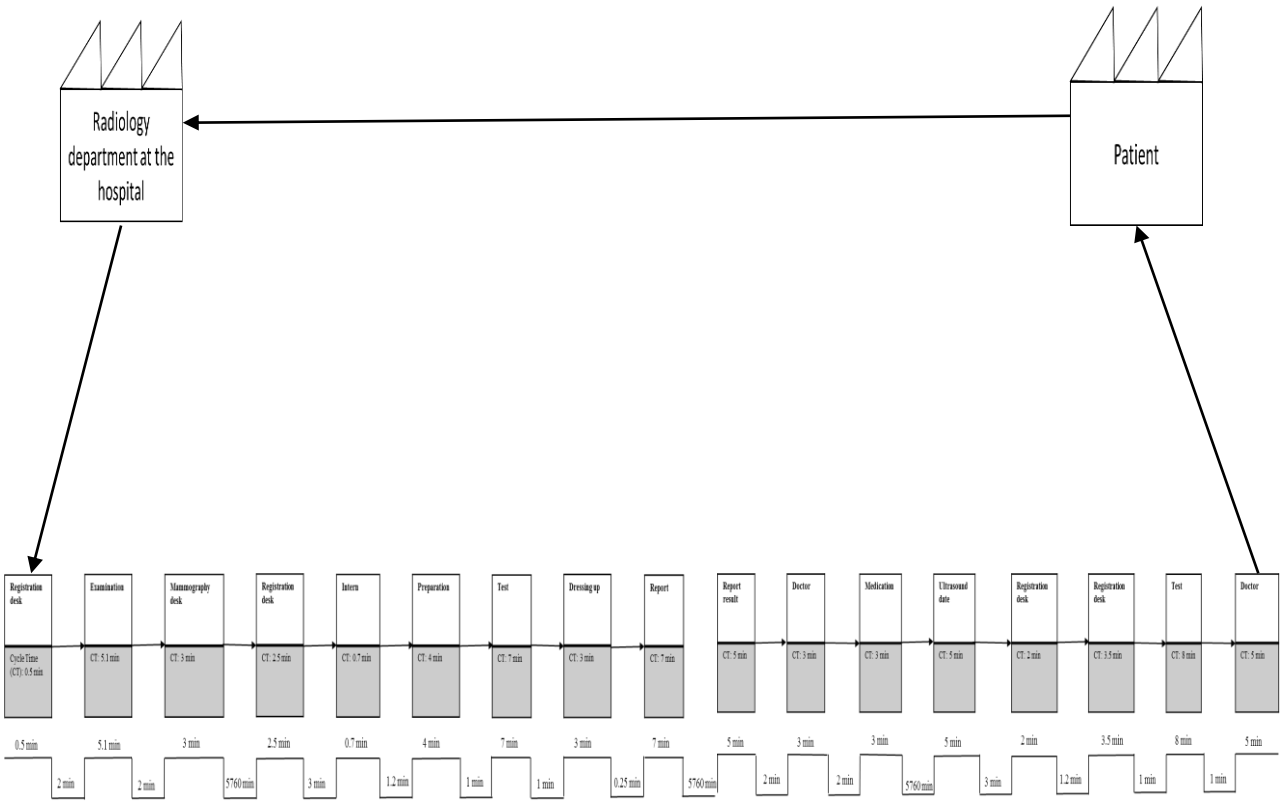

Fig.2: Current State Map.

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ISSN: 0976-3104

Future State of the radiology department

Improvement areas are shown in future map [Fig. 3]. As it is seen, total lead time of the patients' road, which starts from the beginning of the radiation department and ends after the doctors' reporting, decreased nearly 9 days which means a big improvement. As it is seen from the future map, preparation, test, dressing up, report and report result process cycle times are decreased by some technological and physical changes in the hospital. With more than one dressing room, patients will not have to wait for other patients to enter the mammography room. Another improvement area is technologically developed computers and systems. With the simultaneous voice transformers doctor can dictate the result and the nurse can directly take out the report. After the improvement, maximum one day later, the report can be delivered to the patient. Waiting a mammography result is nearly 4 days at the current situation that means extending the treatment process.

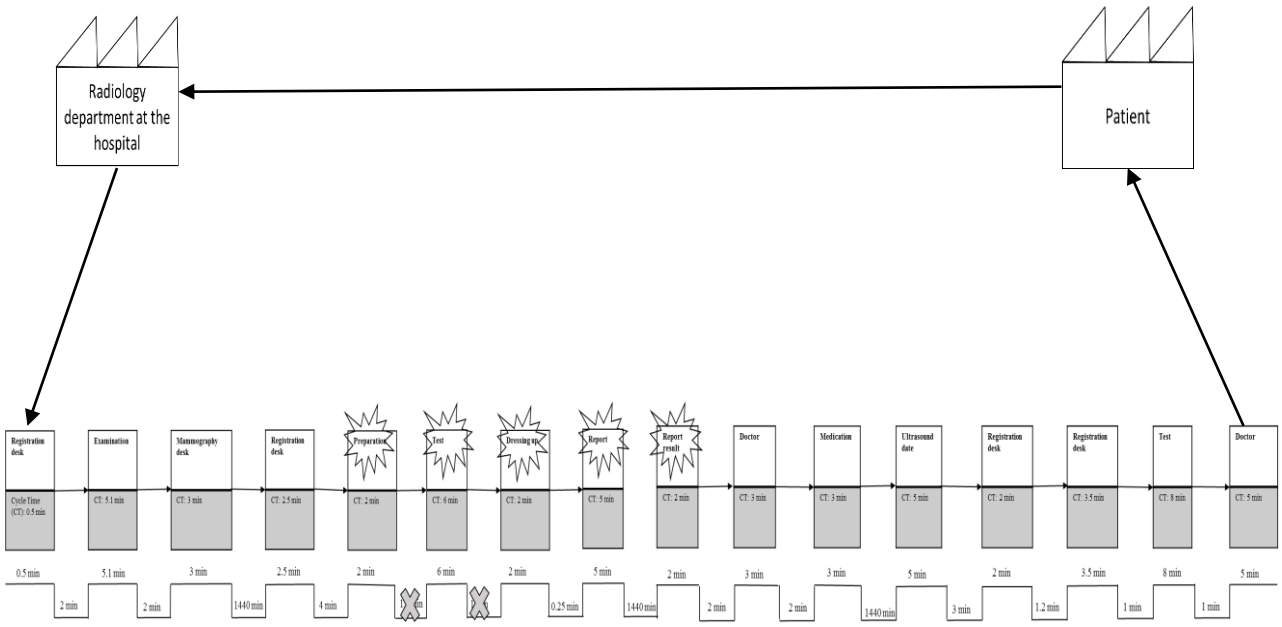

Fig.3: Future state map.

With the correct arrangement of appointments and the required test plan, patients will come on time and will not wait for long queues. In front of the mammography and ultrasound rooms there may be electronic screens to show the coming appointment. This will also improve satisfaction at a less crowded hospital isle.

Linkage of the process improvement of radiology department to industry 4.0

Traditional changes about data collection in manual mode made differences by the large adoption of IoT (Internet of Things). Especially, parameters of the production process can be recorded in various and automatically in a way of timely manner. It can be remarked that traditional industrial production only communicates with M2M technology, but IoT is able to make perfect connections between people, machines and physical objects [17].

Exchanging data and information, any technological devices in the Internet of Things make possible to reach other devices around the world at high speed. Not only the situation of individual devices but also the devices around each other can be reached by up-to-date information in minutes. The physical distances are not important to monitor or operate technology infrastructure. Optimal coordination and controlling are enabled to understand and obtain a large variety of complex technological devices [18]

In a general word, computers, tablets, intelligent devices make enable to connect to internet. Now, it is clear that even healthcare devices such as heart pressure watches, body temperature devices, which are advanced and intelligent devices, can be connected to internet and the information in these devices can be incessantly transferred. Healthcare is just applicable area of IoT alongside smart cities, smart traffic control and weather monitoring [19].

Considering that IoT, the leading time and processing time can be measured by the applications of IoT. As an example, the queue time in a mammography department of any hospital can be optimized and industry

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ISSN: 0976-3104

4.0 makes possible to have an optimized sequencing and shortened queue time which increase efficiency in a technological way. The screenings will aid to shorten waiting time and will facilitate processing in the indicated department. The process improvement, which is indicated by using Value Stream Map as indicated in [Fig. 4], is definitely facilitated by the applications of IoT and Industry 4.0 in the 21st century.

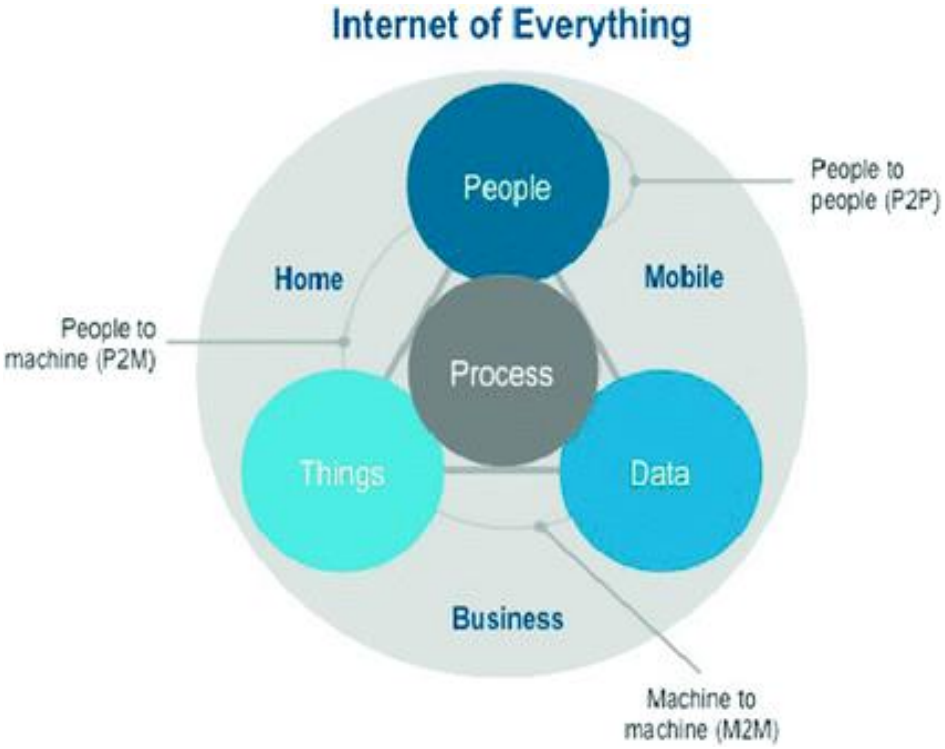

Fig.4: Internet of things (IoT) coverage (19).

CONCLUSION

For current situation, new technological mammography and ultrasound devices are needed to increase the level of patient treatment at the same time and to decrease waiting times. The IoT will lead connecting every machine together that means sending results of a patient will be done simultaneously. Similar to the future state map, writing and giving a report to a patient will not take any time so that patient satisfaction will increase.

Another IoT application can be connected directly with a healthcare system mobile application which will connect with the new appointment screens. A reminder will notify the patient from her mobile phone so that they will not have to wait at the corridors of the hospital.

All in all, an improved value stream map is created which eliminates non-value added processes of the current flowchart. In consideration of all these outcomes, it is suggested for the hospital to apply these improved suggestions which are further explained and aligned with lean application methods.

For further studies, with the discussions with the doctors and planners at the hospital, it can be searched if scanning patient with ultrasound and mammography in the same day may be possible or not. The personnel and technological capacity should be clearly defined to make a detailed plan. With the help of new industry 4.0 applications it would be more easy and effective to reach a high level of patient satisfaction and a high level of healthcare system quality.

CONFLICT OF INTEREST
None

ACKNOWLEDGEMENTS
None

FINANCIAL DISCLOSURE
None

IIOAB JOURNAL
ISSN: 0976-3104

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