Proceedings of the International Conference on Industrial Engineering and Operations Management
Toronto, Canada, October 23-25, 2019

Application of Lean Management Systems in Pathology Laboratory Work Process and Laboratory Environment

Hatice Camgoz Akdag
Management Engineering Department
Istanbul Technical University
Istanbul, 34367, Turkey
camgozakdag@itu.edu.tr

Hür Bersam Bolat
Management Engineering Department
Istanbul Technical University
Istanbul, 34367, Turkey
bolat@itu.edu.tr

Ahmet Haşim Arslan
Management Engineering Department
Istanbul Technical University
Istanbul, 34367, Turkey
hasimars@gmail.com

Ecem Karacakaya
Management Engineering Department
Istanbul Technical University
Istanbul, 34367, Turkey
ecemkaracakaya@gmail.com

Abstract

The purpose of this paper is to design a future value stream map of the system and pathology laboratory process with lean health care application tools in terms of quality improvement in order to decrease the non-value-added activities for pathology unit in a public hospital based in Istanbul, Turkey. This paper aims to decrease waiting time, sample rejection, mistake, manual processes, and disorders as well as increase the suitability of laboratory environment and work safety. Data are collected from personal observations, information technologies unit, and authorized employees. In order to measure sub-processes, some qualitative data are transformed into quantitative data via authorized employees' experiences. Moreover, data tracking and keeping systems are too poor for revealing the current situation. The current value stream map of the system of the radiology department of a public education and research hospital was analyzed and the future value stream map of the system and pathology pathway was redesigned with lean health care application tools in terms of quality improvement. The greatest limitation is the resistant to change and fear of talking on mistakes and low performances. This paper states an example of a current and future value stream map showing systematically where the bottlenecks are and how these can be improved and what specific benefits will this analysis bring to the health care system. It will be useful for both academicians and practitioners on how to apply lean to health care.

Keywords
Lean Management Systems, Pathology Laboratory, Work Process, Value Stream Map

1. Introduction
This study focuses on application of lean management systems in pathology laboratory work process and laboratory environment. One of the reasons for choosing pathology laboratory is crucial for diagnosis diseases. Due to diagnosis of crucial diseases, it makes the pathology laboratory important. The slightest mistakes in pathology laboratory can lead to enormous results in diagnosis assessment. In addition to this, lean management tools do not apply widely in pathology laboratory work processes in hospitals, which leads waste of time and cost. This study can be practicable in other hospitals and pathology laboratories.
The scope of the project is designing and improving pathology laboratory work process at an Education and Research Hospital at Istanbul via lean management. The first part of the study will include the research about the literature review, where initially process management and process improvements described followed by lean management methods and applications. The findings about lean management draws attention on the lean management in healthcare and international laboratory quality standards. Subsequently, the literature review follows with a detailed examination of the pathology which includes definition, importance of pathology and pathology work processes. Work processes explained systematically from fixation of tissue until specimen identification to archiving.
The methodology includes observation, focus group interviews. The final findings of focus group interviews will be defined with illustration. Through need analysis, problems in pathology lab will come to exist.
Analysis of the current pathology laboratory work process and bottlenecks are explained. Detailed workflow are drawn for each step of process. Bottlenecks and performance parameters are defined. Proposals of solution are given. Application of proposal solutions to eliminate bottlenecks in work flow are shown including six sigma applications to decrease rejected sample, macro digital imaging cabin and designing archive systems via 5S rules. The last part of the study are evaluation and conclusion. In addition, constraints experienced, future expectations and suggestions are explained in detail.

2. Literature Review
In the literature review, titles of the process management, process improvement, international laboratory quality standards, and information about pathology are mentioned.

2.1 Process Management
Process management is a series of activities designed to ensure continuous and regular tracking and development of processes (Bozkurt, 2003). Within the context of process management, the processes carried out within an organization should be defined based on processes and maintained, updated, and improved in line with the goals and targets (Aras, 2005). Process management is a management philosophy that encompasses the policies, strategies and systems of enterprises, and accordingly organizational structures, which are "Process Focused" that are continuously evaluated, analyzed and developed. In this understanding, process definitions, process owners, responsibilities and team should be defined, flow mapping and continuous improvement of processes should be balanced with the triple "quality, cost and speed" in products / services and customer satisfaction should be the foreground (Okay, 1999).
Management experts state that only 15% of operational problems in a company are attributed to people (attitude and insufficiency of the personnel themselves) and 85% to process-organization and control problems. It means that even successful people can make mistakes easily in the absence of a good organization and process structure (Moral, n.d.).

2.2 Process Improvement
The first step in process improvement is an examination of the current processes to clarify what is occurring and identify alternatives for improvement. It is then decided whether the process is to be designed from scratch, or whether small changes are made in the current process (Filiz, 2008). On the basis of process improvement underlies unstated assumptions and stereotyped activities. The creation of new rules in accordance with the new standards requires restructuring of the operating processes. Continuous improvement, continuous development, process development and reengineering are concepts that replace each other. All businesses operate in a competitive environment need to constantly renew themselves to provide excellence in their processes. Continuous improvement is an important strategic key that enables the business to be competitive according to its competitors. Continuous improvement work encourages innovation in business as well as continuous development of existing practices and methods. Furthermore,

continuous improvement should be seen and used as a follower of development and innovation in delivering value to customers. Continuous improvement aims to develop these performance parameters below (Kaygusuz, 2014).
• Reducing the costs of products,
• Increase the quality of the products and
• Efforts to reduce time spent in the process.

2.3 Lean Management Methods

Lean manufacturing is a production system that makes use of production factors in a flexible manner with the least wastage to be able to fully meet customer demand, using the least resources possible and the cheapest and faultless production as soon as possible. (Lopez,Santos, and Arbos, 2013). The main purpose of lean methods is to reduce and eliminate wastes that are often seen in businesses. Attempts to continually reduce and eliminate these waste results in large reductions in costs and cycle times (Alukal, 2013).

2.3.1 Lean Management in Healthcare

It provides an opportunity for staff to empower and enrich their business to use lean tools in the solution of simple thought difficulties and bottlenecks in health care enterprises. It facilitates improvements by reducing the costs of healthcare enterprises and improving their capacities. It also improves patient safety and quality by reducing waiting times and work processes, and improving patient flow, and improves patient satisfaction by reducing or eliminating wastes through a patient's care (Naraghi and Ravipati, 2009).Womack and Jones have been among the first writers to propose how lean techniques can be applied to the service sector, particularly health services (Jones and Womack, 1996). List basic performance criteria (basic steps) of implementing lean thinking and system in health care;
• Prioritize the patient,
• Providing quality,
• Creating a highly skilled patient care team in patient care,
• Ensuring active participation of the patient in the patient care process.
Lean principles are intuitive and compelling (Lazarus and Andell, 2006), they can therefore be easily understood and used by the hospital staff. . The Lean approach targets the reduction and the elimination of every type of waste, which is a recurrent problem for hospitals (Murphy, 2003). This was, for example, underscored by Bush in an article published in the Journal of the American Medical Association in 2007 (Bush, 2007), in which he recommends adopting a lean approach.
However, examples of hospitals that have adopted a “principle-driven” lean approach are still rare (Curatolo, 2014). Most cases report narrower technical applications with limited organizational reach, and focus mainly on applying Lean techniques and tools to a unique process or ward rather than implementing a Lean philosophy in the whole hospital (Mazzocato et al., 2010).

2.4 International Laboratory Quality Standards

There are many internationally accepted standards for laboratories and many of these have been enhanced by ISO. Standards provide to give preferred features of products and services such as quality, safety, reliability, efficiency and reproducibility. ISO standards have no legal obligation to implement, but they are approved everywhere in the world. For the healthcare, there is the ISO 9000 series, which includes managerial procedures. ISO 15189 includes both technical and management requirements for medical laboratories was officially launched in 2014. Each country wants to adopt existing international standards, while deciding which standards conform with their situation. While quality standards are being developed, consultation should consist of stakeholders including the MOH and other relevant government Laboratory Quality Standards, the national laboratory focal points, national regulatory authorities, laboratory network representatives, including disease program managers, representatives of the relevant professional organizations, research and educational institutions, legal counsel, health managers and civil society and private laboratories (World Health Organization, 2010).

2.5 International Laboratory Quality Standards

Pathology that is used to diagnose many diseases is a medical specialty area that explains the nature and causes of diseases. It supports monitoring of chronic diseases and every aspect of medicine such as blood transfusion technologies, technological genetic research, and diagnostic tests. It is used especially in the diagnosis of each cancer case. It uses various samples (cells, organs, tissues and body fluids) and methods to diagnose the disease and covers many scientific disciplines (“The economic value of pathology: Achieving Better Health and a Better Use of Health Sources Report”, 2016). In this context, it is divided into general pathology and special (systemic) pathology;
1. General pathology deals with the abnormal state of cells or tissues underlying all diseases.

2. Systemic pathology deals with the identification of defined conditions in a definite diagnostic process, or the elimination and delimitation of diagnoses, and the specific responses on organs and tissues.
General pathology is an important part of the pathology diagnosis process. The patient's clinic that is applied in other departments, and other laboratory results are the sources that pathology specialist use to prepare pathology reports. For this reason, the pathology specialist doctor can also interview and examine the patient if it is necessary ("Patoloji Bölümü-Laboratuvar Test Rehberi", n.d., p.167).
Pathology diagnoses 70% of all diagnosis made in the NHS (National Healthcare Service). Pathology has big role in screening and monitoring, and precisely in management of chronic conditions. Also, Pathology operates by merging multidisciplinary teams. It is not only a diagnostic tool but also provides direct patient care in the case of many specialists ("Digital First: Clinical Transformation through Pathology Innovation", n.d., p.9).
Pathologists, medical specialist, are sources as proposals for many doctors. They have knowledge about making proper tests, interpretation of results, finding best treatments that can be used, and the development of advanced technology tests ("The economic value of pathology: Achieving Better Health and a Better Use of Health Sources Report", 2016).
Patients are not only give attention to test results, also trust clinical pathways such as having access to efficient, timely and cost-effective pathology services. Following new technologies in pathology has important effect to give efficient healthcare service to patients ("The economic value of pathology: Achieving Better Health and a Better Use of Health Sources Report", 2016).
Samples to be examined by pathology are mainly evaluated in two groups. "Biopsy Report" is the first group of samples and "Cytology Report" is the the second group. Biopsy is defined as tissues / organs removed from the body by small or large surgery. Cytology is defined as cells taken by the needle from the body, spontaneous cells or body fluids. (The most common of which is "cervicovaginal smear") (Celasun, 2014). Biopsy and cytology report process divide macroscopy, microscopy and histopathological diagnosis. In the macroscopy section, the visual characteristics such as what kind of sample is, how many, how it looks, where and how many representative samples are taken are indicated. After all normal and abnormal findings on the microscopic examination are given, it is interpreted which disease may be compatible with the abnormal findings. In the histopathological diagnosis part, thediagnosis is indicated by the evaluation of macroscopic and microscopic findings together. All of these sections contain medical terms that the patient cannot understand because the pathology report is written for the doctor who follows the patient, not for the patient. This doctor will also provide the necessary explanation to the patient (Kalyoncu, 2013).
Pathology process is directly related to other departments of hospitals. Small biopsies are coming from the department such as gastroenterology, plastic surgery to the pathology laboratory; larger tissues and organs than the operating rooms; gynecological diseases and obstetrics, endocrinology, radiology, cytological materials (spreads and fluids), and in some cases to direct the surgery, in order to determine the extent of the operation to be done, frozen tissues for emergency examination called frozen. The samples to be examined as frozen are sent to the laboratory in an emergency without being placed in any liquid, while small biopsies and larger tissues are stored in 10% formaldehyde solution; the cytological specimens are either spread on the slide or sent to the laboratory in the syringe (Kalyoncu, 2013).

3. Methodology

The total group of 22 people who are working in Pathology Laboratory at the selected hospital was given a brief oral description of the project and were invited to volunteer their services as focus group. There were 3 meetings in all.
The pathology laboratory was observed briefly to understand the work process in deep. The laboratory workers were observed during their daily work, as well as some questions were asked to determine daily work process.
First meeting was to understand the current situation and current work flows to create current value stream map. Later, second focus group interview helped the detailed work process to be established. The current value stream map (VSM) was analyzed together with the focus group and bottlenecks and problems were determined. Lean technique suggestions were given and some were implemented. The last focus group meeting gave the feedback for the future value stream map. The focus group consists of laboratory secretary, laboratory technicians, laboratory doctors, and biologists.

4. Findings

After focus group interviews, problems were determined as listed below.

- Laboratory environment is not suitable for work safety rules. Assistant doctor and laboratory technicians explained that laboratory air condition does not work. There is intensive formaldehyde smell that is coming from specimens. This chemical affects people that works in macroscopy because they breathe this kind of chemical. Nobody controls work safety rules such as obligation about masks, laboratory scrub or glass.

- Old equipment is used by laboratory assistants and laboratory technician, which causes risks for laboratory assistants. For example, the knife used by the assistant doctor was so old that he could be injured and infected while cutting the specimens.
- There laboratory environment is dirty. Macroscopy cabin and embedding device are not new technology and not hygienic shown in Figure 2 and Figure 3. In addition, grossing place is not hygienic and suitable for proper ways shown in Figure 4.
- There are many cases coming in a day (average 100 biopsy, 60 cytology). It causes over workload for all Pathology workers.
- There are insufficient laboratory materials. Laboratory cabins are old fashioned and not technological. Tissue tracking device takes 8 hours to prepare tissue. Microtome, grossing equipment are old when compared with other laboratories.
- There are many manual work processes. Laboratory secretary have to control rejection criteria with observation and record data in notebook manually.
- There is unconditional physical environment. Macroscopy cabin, chair and room layout are not ergonomic.
- Archiving parts of specimens causes disorders in laboratory. Also, there are many useless machines on the shelfs shown in Figure 1.

Figure 1. Archived Samples

Figure 2. Current Macroscopy Cabin

Figure 3. Current Grossing Place

Figure 4. Current Embedding Place

4.1 Current Pathology Laboratory

After first focus group interview, flow of detailed work process is drawn. In order to improve the process and decrease the waste, a current value stream map was created. For the activities seen on the map, durations were observed and found by time studies and responsible people for each activity specified. According to the bottlenecks, system and process analyses, and the study findings, key performance indicators were defined for evaluating the processes more efficiently and for categorizing whether the processes were qualified or not. In that regard, quantitative indicators were listed, and the method for collection of the data, explanations, and current value sections were shared for consideration. The VSM is separated into sample admission, macroscopy, microscopy, reporting and archiving work process shown

in the next three figures (figure 5, 6, 7). Total standard time of process is calculated average 7 days. Circled numbers in flows define bottleneck numbers.

Pathology examines two types of samples such as biopsy and cytology according to literature review. The reasons why biopsy pathologic process is chosen, is because it is more complex than cytology. Focus group members stated that the cytology process have already more systematic flows and applications rather than biopsy process.
Figure 5, shows current PL sample admission, Figure 6 shows macroscopy and Figure 7 shows microscopy-reporting and archiving work process.

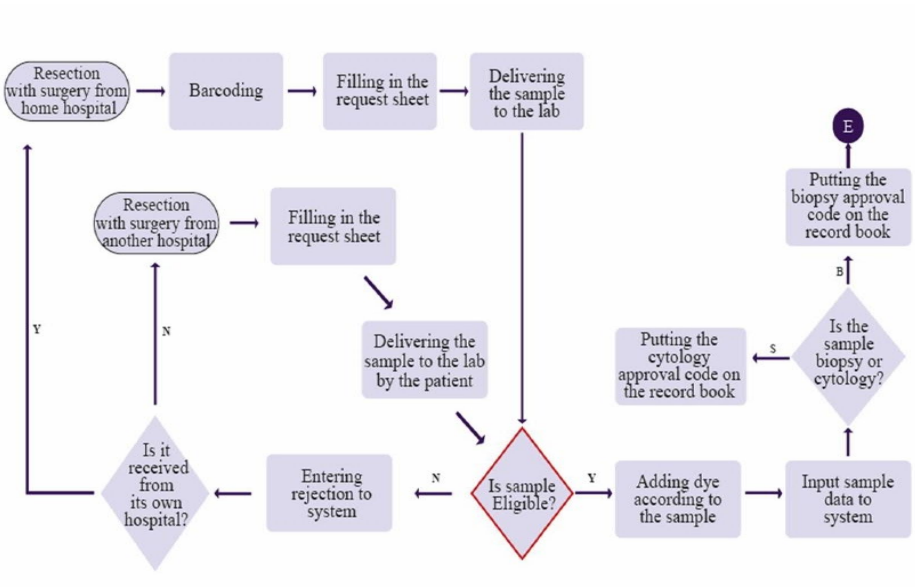

Figure 5. Current PL Sample Admission Work Process

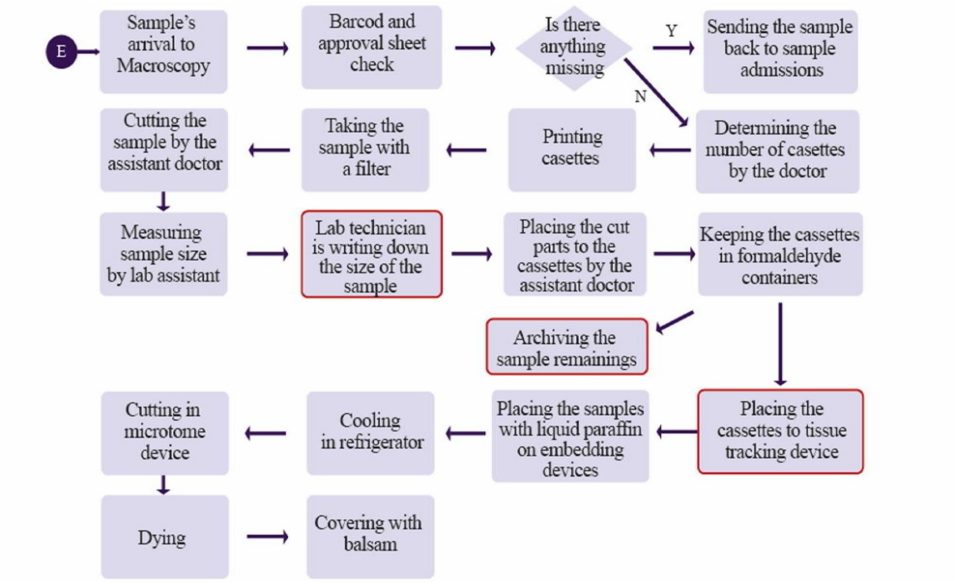

Figure 6. Current PL Macroscopy Work Process

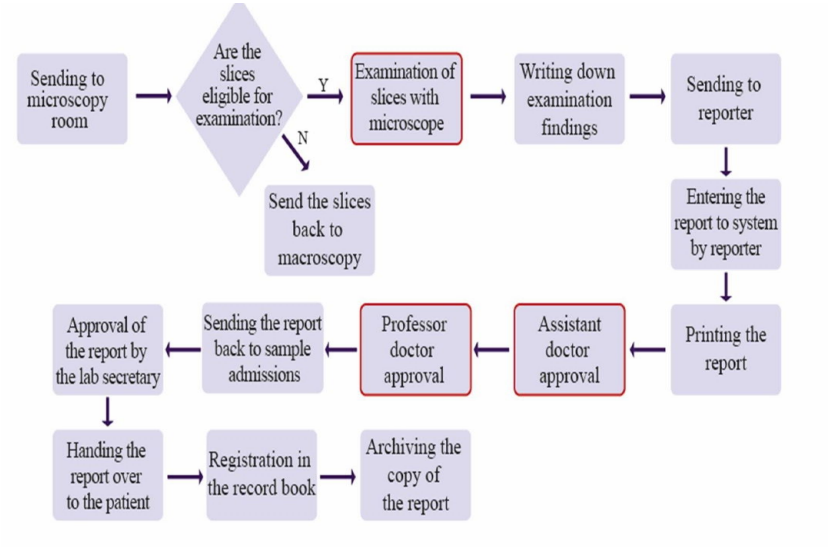

Figure 7. Current PL Microscopy-Reporting and Archiving Work Process

4.2 Bottlenecks and Performance Parameters

After second focus group interview, bottlenecks and performance parameters were determined with detailed work process flows. Table 1 explains each bottleneck, which shows the detailed work process flows. In addition, it shows performance parameters that provide measure of bottlenecks by units such as time or cost.

Literature review and focus group interviews provide quality methods, proposals and tools of analyzing. Table 2 shows each bottlenecks' performance parameters and quality methods chosen to improve these selected bottlenecks. Also, proposals identify how quality methods will apply and tools of defines which quality tools will help to improve bottleneck problems.

Table 1. Bottlenecks and Performance Parameters

Bottleneck No.	Bottleneck Explanation	Performance Parameter	Parameter Unit	Parameter Metric	Work Process
1	After the delivering sample to the laboratory, laboratory secretary controls sample whether eligible or not. If sample is not eligible, sample rejection is entered to system. Then, rejection sample is going back till being eligible according to rejection criteria.	Average time per each rejected sample till being eligible	Time	3 days	Sample Admission
2	After assistant doctor measures sample size, laboratory technician is writing down the size of the sample by hand. It causes mistakes as well.	2 laboratory technicians working for it	Time Cost	45sec 2*wages	Macroscopy
3	After specific parts of samples that specified according to diagnosis are cut by assistant doctor, remaining samples achieve on the cabin shelf with no any specific order.	Average time of looking for remaining samples by assistant	Time	1.5 min.	Macroscopy
4	After assistant doctor put the cassettes in	Waiting time of samples in tissue tracking devices	Time	14 hours	Macroscopy

	formaldehyde containers, he places the cassettes to tissue tracking device overnight.				
5	After slices are come from macroscopy, if the slice is eligible for examination, it is examined by professor doctor with eyes.	Average Time of Examination	Time	45 min.	Microscopy
6	After microscopy, reporter is entering the report to system. Then, printed report is sent to assistant doctor approval sign firstly. Finally, it is approved by professor doctor sign.	Average Waiting Time	Time	5 hours	Reporting

Table 2. Proposals of Solutions

Bottleneck No.	Performance Parameter	Parameter Unit	Parameter Metric	Quality Methods	Proposals	Tools of Analyzing	Work Process
1	Average time per each rejected sample till being eligible	Time	3 days	Lean Management Methods	Application in Decreasing Numbers of Rejection	* Fish-Bone Diagram * Pareto Analysis *Six Sigma	Sample Admission
2	2 laboratory Technicians working for it	Time Cost	45 sec 2*wages	Lean Management Methods	Purchasing Macro Digital Imaging Cabin	*Cost-Benefit Analysis * Break-even Analysis *Cost-Effectiveness Analysis	Macroscopy
3	Average time of looking for remaining samples by assistant	Time	1.5 min.	Lean Management Methods	Designing archiving systems with barcodes or labeling methods	*7Waste *5S	Macroscopy
4	Waiting time of samples in tissue tracking devices	Time	14 hours	Lean Management Methods	Purchasing new tissue tracking machine	*Break-even Analysis *Cost-Effectiveness Analysis	Macroscopy
5	Average Time of Examination	Time	45 min.	Lean Management Methods	Hiring a new pathologist	*Cost-Effectiveness Analysis	Microscopy
6	Average Waiting Time	Time	5 hours	Lean Management Methods	Transferring procedure to e-signature	*Break-even Analysis *Cost-Effectiveness Analysis	Reporting

5. Results of Lean Management Application

Six sigma was applied to improve the process and decrease rejected samples. The rejection sigma level of the sample was increased from 3.61 to 3.9 and the DPMO value decreased from 29.665 to 12.041. This means that 29.666 out of every million receiving samples from pre-improvement were wrong (at 3.61 sigma), 8.532 out of every million receiving samples from post-improvement were at fault (at 3.9 sigma). Basically, this increase in sigma level has been realized in a short time, so long term effects of the improvements should be examined. It seems that the misapplication has decreased after improvement. It is possible to say that these applications have more potential for improvement. Since the mistakes that employees make especially due to carelessness cause variability. It is necessary to standardize these processes with trainings to be given.

In pre-improvement there was 372 rejected samples for 6 months it means 62 rejected samples per month. It is assumed that the number of rejections for 6 months after improvement will decrease to 151. That means 25 samples were rejected in 1 month. This means that approximately 37 patients have been prevented from receiving the issued report by waiting three more extra days. The total refers to 111 days. Taking patients' reports in the expected period is important for starting early treatment. Six sigma application will contribute to early detection applications. At the same time, it will become a tool for educating conscious staff.

It is possible to mention some limitations because the employees of the hospital are not sufficient for information infrastructure of Lean Six Sigma where the implementation is carried out and since there is no time to implement the six sigma after improvement. These limitations can be explained as the records are not kept properly at the Pathology laboratory they are not willing to share information. This model was created by making assumptions in the light of limited information that is obtained. It is expected that this application will also be model for other hospitals.

In this context, the 5S application which is a superior improvement tool that has been used by the industry, includes some advantages such as encouraging employees to participate in and to help increase the productivity. The main aim of this improvement is to implement 5S methods in pathology laboratory for archiving system. Firstly, 5S training will be given to management and employees, the main steps of 5S (Seiri: Sort, Seiton: Set in order, Seiso: Shine, Seiketsu: Standardize, and Shitsuke: Sustain) was implemented.

In conclusion, cabinets were arranged according to 5S rules. The following improvements were observed due to 5S implementation.

• Average time of looking for remaining samples decreased from 75 sec to 15 sec. (calculated by stop watch time study).

• Average 10 samples are re-examined per day, which means that an assistant will save 12,5 min per day. (75 sec x 10) Assistant doctor can process 5 more samples in the waste of time (12,5 min waste of time / 2,5 min average process). It means five more patient's sample can process.

• Before 5S, total 100 sample was processing. After that, 105 sample can be processed within the same time. Resulting in 5% efficiency increase.

• Working more ergonomic conditions. The assistant doctor will walk less (decrease from 15 steps to 5 steps), so working fatigue will decrease. (calculated by stop watch time study technique).

• Providing to work in a cleaner environment

• Possibility to work in a tidy environment

As analysed in the previous value mapping, one of the most critical bottlenecks is the waiting period of diagnosis in microscopy. In the current process, an average tissue waiting period is 33 hours that equals roughly 4 business days. Diagnosis is the most significant part and requires expertise. Even though doctors may diagnose the problem approximately in an hour, because of the lined-up tissues from previous days, this procedure takes over 4 days.

In this study, firstly the processes, which are performed in the Education and Research Hospital Pathology Laboratory, were determined. Value Stream Map (VSM) was used and thus efforts were made to determine non-value-added activities. In the context of the VSM application, the current situation map is drawn and it is revealed how exactly the work process is performed in the current situation. Bottlenecks where figured out and lean techniques were suggested as shown in the current situation map in Appendix 1a. A number of proposals have been developed for the solution of these identified problems. Suggestions for improved solutions are shown in the future state map (Appendix 1b). It is predicted that significant improvements will be made in the Education and the Research Hospital PL if the lean management methods is applied in the current situation map. Lead time (LD) is decreased from 7 days to 4.95 days, which means that the pathology result report improves by %30 (7 days-4.95 days). Process time (PT) has decreased from 16 hours 11.5 minutes to 5 hours 11.05 minutes, which means that the amount of time work process for one sample improves % 67 (16hours 11.5 min.- 5hours 11.05min.).

6. Conclusion

Pathology has a major impact on diagnosis and, consequently, on treatments for many diseases. It provides relation between science and medicine that underpins every aspect of patient care, from diagnostic testing and treatment advice to the use of cutting-edge genetic technologies and the prevention of disease. Millions of pathology tests are carried out each year. Major advances have been made by pathologists, from breakthroughs in the successful treatment of cancer and the safety of blood transfusions, to treatment for inherited conditions and vaccinations against infectious diseases. Pathology is involved in over 70% of all diagnoses made in the NHS. That is why, the pathologist must carefully assess all clinical findings. According to literature review Pathology has critical importance. However, Pathological work process does not have standard process and automatization such as microbiology and hemogram laboratory tests. As a result of these, many mistakes in pathology laboratory can lead to improper results in diagnosis assessment. In addition to this, lean management tools are not applied in current pathology laboratory work processes.

It leads waste of time and cost. One of the most crowded Education and Research Hospital was chosen to apply lean management methods. In this study, focus group interview is made in order to determine need and problems. As result of findings, detail work process flows were created to understand bottlenecks. In order to improve the process and decrease the waste, a current value stream map was created. For the activities seen on the map, durations were observed and found by time studies and responsible people for each activity specified. According to the bottlenecks, system and process analyses, and the study findings, key performance indicators were defined for evaluating the processes more efficiently and for categorizing whether the processes were qualified or not. In that regard, quantitative indicators were listed, and the method for collection of the data, explanations, and current value sections were shared for consideration. According to literature review, suitable lean management methods were matched with each bottleneck. Briefly summarizing the findings, six sigma was applied to decrease number of rejected samples. As a result of this, 37 patients have been prevented from waiting 3 days to get report in one month period. Secondly, a new digital cabin was suggested to be purchased that could provide 36 extra sample examinations per day. After that, 5S rules were applied for achieving system in macroscopy. 5S implementation provided a clean and tidy environment. The clean and tidy environment provided five extra samples to be examined per day. A technological device was suggested, as it will decrease processing time from 14 hours to 3 hours. In saved time, 66 more samples will be processed. Another improvement suggestion was for microscopy unit. As seen in the current value stream map, one of the most critical bottlenecks is the waiting period of diagnosis in microscopy. The waiting time decreases of 8 hours from 33 hours to 25 hours. The last improvement is to transfer from manual signature to e-signature. The e-signature decreases the signature process from 5 hours to 1 hour. In conclusion, getting result decrease average from 7 days to 5 days by applying the lean methods.

Even though there are still manual processes in macroscopy such as embedding and microtome devices using the new technology would automatize the process in future. Lean techniques are possible to implement at other pathology laboratories in different hospitals which will also have promising results. Many hospitals have similar manual activities such as manual signature, achieving system. Most of pathology laboratory have similar process, so methods used in this project can be practicable in other pathology labs.

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

References

Alukal, G. “Create a Lean, Mean Machiene”, Quality Progress, 2003, 36 (4), 29-34.

Aras, A.A. (2005). Sürdürülebilir Süreç Yönetimi. İstanbul: Kalder.

Bozkurt, R. Süreç İyileştirme. Ankara: Milli Prodüktivite Merkezi Yayınları, 2003.

Celasun, B. Patoloji Raporları. Retrieved from: http://patoloji.gen.tr/patoloji-raporlari/, 2014. [Accessed 25 Oct. 2017].

Curatolo, N., Lamouri, S., Huet, J.C., and Rieutord, A. “A critical analysis of Lean approach structuring in hospitals”, Business Process Management Journal Vol. 20 No. 3, 2014 pp. 433-454.

Filiz, A. . Üretim Yönetiminde Verimlilik Sırları (1.Edition). İstanbul: Sistem Yayıncılık. 2008.

Kalyoncu, Ş.. 10 Soruda Patoloji. Interview with Dr. A Şafak Bulut. Date Accessed 7 December 2013, Retrieved from http://www.hurriyet.com.tr/10-soruda-patoloji-25295355, [Accessed 3 Nov. 2017].

Kaygusuz, S., Kaygusuz, Y. Süreç İyileştirmenin İşletme Performansına Etkileri. Paradoks Ekonomi, Sosyoloji ve Politika Dergisi. 2014 10.2: 31-50. Retrieved from http://paradoks.org/components/articles/articles/show/2777EVA100344180914., [Accessed 12 Oct. 2017].

Lopez, A., Santos, J. F. and Arbos, L. C., “Lean Manufacturing: Costing the Value Stream”, Industrial Management & Data Systems, 2013, (113), 5; 647-668.

Moral, T. (n.d). Müşteri Gözlüğünü Takmak: İş Süreçleri Yönetimi. Retrieved from www.sistema. com.tr, [Accessed 16 Dec. 2017].

Naraghi, A. M. and Ravipati, U. P.,. “Lean Healthcare in the Emergency Ward of Sahlgrenska Hospital”, University College of Borås, School of Engineering, Master thesis, Göteborg, Sweden, 2009, pp.15.

Okay, I. İşletmelerde Süreç Yönetimine Geçiş ve Uygulama Sonuçları (Master’s thesis), 1999. İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Womack, J. P., Jones, D. T., Lean Thinking: Banish Waste and Create Wealth in Your Corporation, New York: Simon and Schuster; 1996, pp.11.

World Health Organization, Laboratory Quality Standards and their Implementation, 2010, pp.2-3, ISBN 978 92 9022 397 9

Biography

Camgöz Akdağ, H.. PhD on the field of quality, from Brunel University, UK; MBA from Eastern Mediterranean University, Turkish Republic of Northern Cyprus; BA from Bosphorus University, Turkey. Associate Professor at Istanbul Technical University, teaching Production Planning and Control, Quality for Engineers, Fundamental Topics of Production Management, Quality Standards and Certification and Total Quality Management courses. She is currently dealing with lean healthcare applications, value-added activities, specially doing projects on how to improve breast cancer departments patient flow. She has a number of publications on the subject of quality, six sigma and benchmarking and two best paper awards from international conferences.

Bolat, H. B., Associate Professor at Istanbul Technical University- Management Engineering Graduate Program Coordinator, PhD from Management Engineering, ITU, MSc. From ITU Management Engineering Department,

Arslan, A. H. Istanbul Technical University, Management Faculty, Management Engineering Department Graduate, 2018.

Karacakaya, E. Istanbul Technical University, Management Faculty, Management Engineering Department Graduate, 2018.

Appendix 1

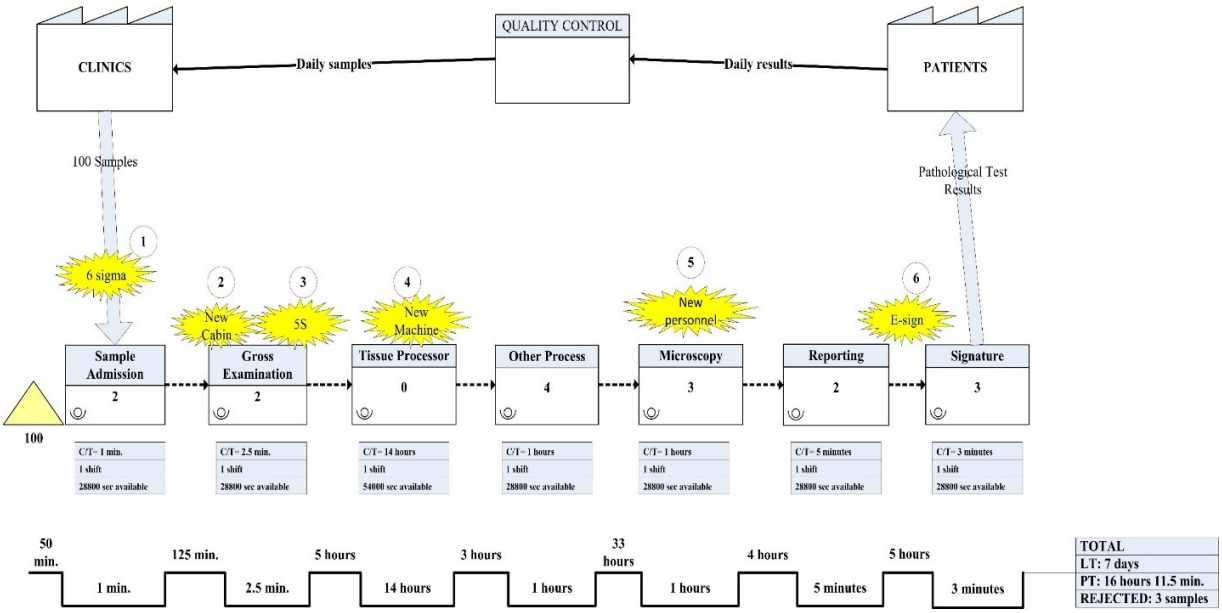

Figure A1. Current Pathology Laboratory Work Process VSM

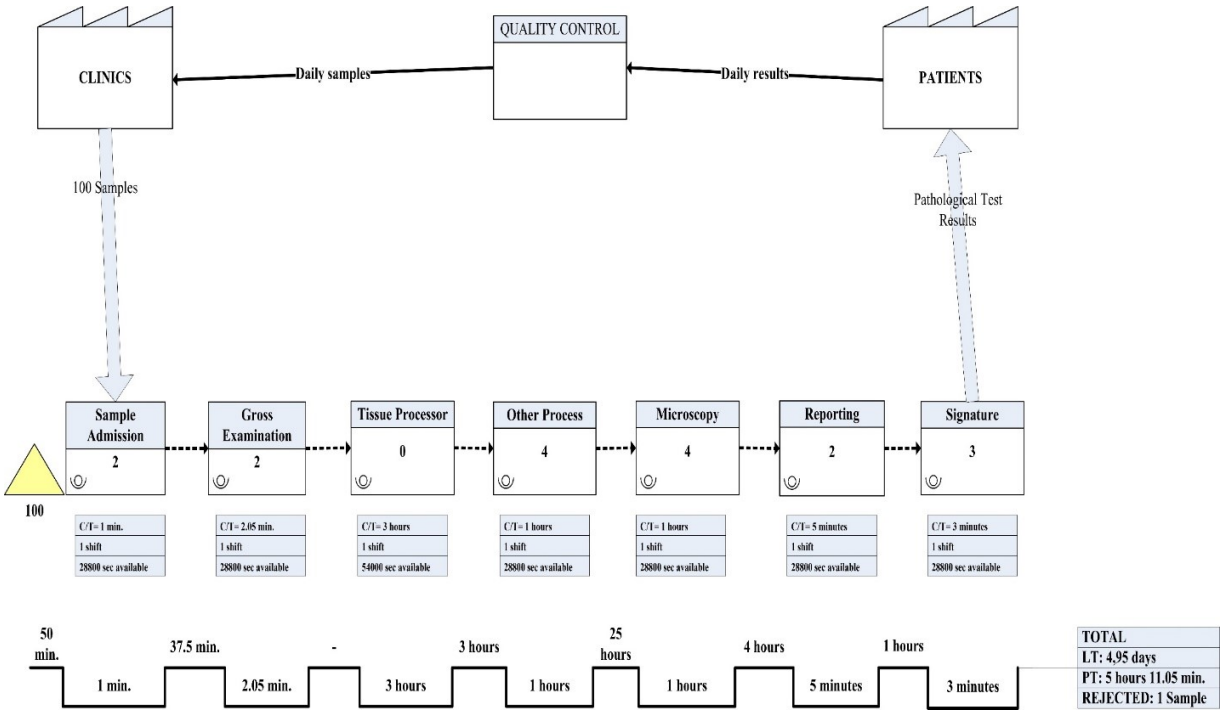

Figure A2. Post-Improvement Pathology Laboratory Work Process VSM