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A Process Improvement Study in an Emergency Department Using Lean Methodology

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Abstract

Lean thinking is one of the most modern and well-established methodologies which provide an effective structure to improve the performance of production and service processes including healthcare systems. The objective of this study is to minimize the length of stay (LOS) of patients at the Emergency Department (ED) by using the principles of lean production, and thus to increase the satisfaction of patients and medical staff. Process improvement methodology and tools were applied in parallel with lean principles to detect the critical quality factors affecting LOS, and to seek non-value added activities in the emergency service processes. Moreover, other tools of Lean-Kaizen such as fishbone diagram, brainstorming, and VSM are used to analyze the root causes of waste and propose the improvements. Appropriate improvements were generated based on lean philosophy coupled with a simulation model.

Keywords

Lean Thinking, Healthcare, Emergency Department, Kaizen, Value Stream Mapping, Simulation

1 Introduction

Healthcare organizations, known as complex business systems, need to balance the amount paid for the medical care services and the overall outcome generated from them considering the needs of relevant expectation groups including patients, workers, hospital owners, etc. [1], [2]. Efforts to achieve this balance should focus on whether (1) the services provided by both public and private healthcare organizations are sufficient to meet the patients' needs and expectations, and (2) the resources are allocated and utilized efficiently [3]. These two issues are especially critical for the management of the emergency care services.

Among others, emergency care services have been recognized as unique and critical units of the hospitals due to a high demand of patients with various and unpredictable cases which may also require different and complex care processes regarding the type and severity of the case. Such services should be provided in a timely fashion and in a correct way, which also requires sufficient service capacity, operational flexibility and speed, and knowledgeable stuff. Overcrowding and long waiting times are reported as the major problem at most of the emergency departments

and are causing not only patient dissatisfaction and complaints but also a high turnover rate of emergency service workers [4], [5]. Consider that nurses specially trained on emergency care are overburdened with other operational and administrative tasks rather than medical care. When this overcrowding is caused by the external factors, such as an increase in population around the hospital and frequent occurrence of ED-related cases, they are not controllable by the hospitals and there is nothing much that a single ED can do to manage it. However, if overcrowd and long waiting times are the results of ED internal issues, such as poor design and management of the ED processes, insufficient capacity, inefficient use of resources, healthcare professionals and managers might have more control over them by implementing some well-known systematic process innovation and improvement activities [1].

In the last decades, lean thinking method has gained a prominent reputation as systematic process improvement initiatives, many times with the integration of six sigma quality management system. A lot of studies have documented the widespread use of these techniques in different industries. Although lean thinking emerged within the manufacturing sector, it has also widely applied to service industries including healthcare services [6], [7]. The lean methodology aims to accelerate the speed of all processes across the enterprise to minimize "waste" [8].

In this research, a study is performed on the effect of using lean methodology on the quality of healthcare services, in order to reduce the Length of Stay (LOS) of patients at the Emergency Department and; therefore, increase the satisfaction level of patients and medical staff. The study was implemented at an ED in one of the Medical Faculty Hospitals of a private university in Istanbul, Turkey.

2 Literature Review

Health care is a complex business, having to balance continuously the need for medical care and attention to financial data. It offers pocket of excellence, with outstanding advances in technology and treatment, together with wastes, inefficiencies, and errors. Pexton, (2003) states that in the today's complex healthcare environment, errors and variability in medical care reduce confidence in the medical community, and measurement of errors is necessary for the design of a quality improvement strategy. She defines the quality in healthcare as 'the extent to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge' [9].

Lean is a strategy that aims to accelerate the speed of all processes across the enterprise system to minimize "waste" in order to improve firm performance [8]. Lean is defined as a way to specify the value, line up value-creating activities in the best sequence, and perform them without interruption whenever requested and more effectively. Lean thinking provides a way to do more with less (less human effort, equipment, time, and space) while coming closer to customers for providing what exactly they want [10], [11].

More recently, lean methodology along with quality improvement techniques and tools have been used in research and development, financial, healthcare, engineering, and construction sectors [2], [12], [13], and have changed the way health managers view their work [15], [16].

According to the Womack and Jones (1996), there are many examples of the positive impact that lean is having not only in manufacturing but also in hospitals throughout the world. The Virginia Mason Medical is one of those hospitals, which reduced incidences of ventilator-associated pneumonia from 34 cases with 5 deaths in 2002 to 4 cases with 1 death in 2004 thanks to lean applications [17]. Intermountain Healthcare is another example which applied lean techniques and reduced the turnaround time of pathologist reports from 5 to 2 days and the time to treatment from 4 h to 12 min [18]. Lean initiatives in 15 emergency departments documented in 18 scientific articles were analyzed in depth by Holden (2011), and the opportunities and positive effects of the lean management practices with their limitations on different issues, such as work structure and process, quality of patient care, patient safety, length of stay, waiting time, personal behavior, etc. were reported [19].

3 Methodology

Lean methodology is related to efficiency and speed and aims to eliminate wastes. Waste is anything "costs, time, work, skill" without any value in the eyes of customers [20]. Transportation, inventory, motion, waiting, overproduction, over-processing, defects, and skills are the most common forms of the wastes, and the following principles are essentials to remove them from the system [10]:

1. Identify Value "from the standpoint of the end customer".
2. Value Stream Mapping "identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value".

3. Create Flow "make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer".
4. Establish Pull System "let customers pull value from the next upstream activity".
5. Seek Perfection "begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste".

The methodology of this current study was also established based on these 5 principles. The case study was performed in a branch of a university hospital, which has become one of the prestigious medical centers in its region for several considerations: the medical care quality, the location of the hospital, and the availability of most medical services 24-hours a day. At the ED of hospital there are waiting area for patients, reception with two employees shared with nurses' office, one emergency doctor room, three examination rooms for diagnoses and one observation room with 5 beds for patients who present to the ED and require a significant period of treatment or monitoring in order to make decision, and one resuscitation room with one bed which used to the most acute patient case which require immediate life-saving intervention, simple surgical operations such as sutures and simple procedures such as change the bandage wounds, giving injections, and etc. The medical staff team per shift consisting of a Charge Nurse, a Guide Nurse, Two Emergency Nurse, an Emergency Doctor and on-call Specialist Doctors.

3.1 Identify Value

3.1.1 Identification of Metrics by Using VOC

Voice of Customer (VOC) is about priorities, expectations, complaints, and comments of the customers who purchase or utilize the services and get the process outputs. In El-Benna (2012), quality performance measures in the healthcare sector are generalized as access to care, the satisfaction of patients and physicians, service time, service cost, labor productivity, reduced overtime, patient waiting times, increased revenues, clinical excellent and enhanced quality of life [21].

In this study, after several meetings with the directors, nurses, doctors, technicians and patients, "quick diagnosis and treatment" requirement was taken more attention from most patients because the time at this emergency department is a very critical factor especially for patients with a serious condition. All patients expressed their willingness to spend less time at the hospital and receive immediate service. Based on these, the Length of Stay (LOS) at Emergency Department was set as the critical metric for the further steps.

3.1.2 Product/Service Families

For identifying the specific service more suitably the groups of services can be mapped, which is a very important task, referred to "product/service families" [22]. The types of emergency services regarding the severity of patient's condition and level of care required for this triage are defined as product/service families in this study. The triage nurse is responsible for evaluating the severity of the patient's condition by using the Emergency Severity Index (ESI) criteria. Triage patients are clustered into five groups from level 1 (most urgent, resuscitation) to level 5 (least or non-urgent), then transferred to an appropriate unit of care. The most acute patient case (Level 1) routed to Critical Care Unit (CCU), the emergent and urgent (emurgent) patient case (Level 2-3) routed to Intermediate Care Unit "Observation Room" (OR), and the low acuity patient case (Level 4-5, less urgent, non-urgent) routed to Diagnoses Unit "Examination Rooms" (ERs) or "Resuscitation Room" (RR). Based on these levels as product/service families and their impacts on the patient requirements general flow of the process was produced.

3.1.3 Construction Flow Chart of Process

The flow chart is constructed for the whole Emergency Department processes as shown in Figure 1. Since the patients with trauma and multi-organ failure (Level 1) takes more time, sometimes more than 24 hours, Level 1 is not considered in this study. Furthermore, we decided to remove the last step (Exit) from the flowchart because we cannot control the time when the patient will exit from the ED gateway as this time very much depends on the patient and his/her family.

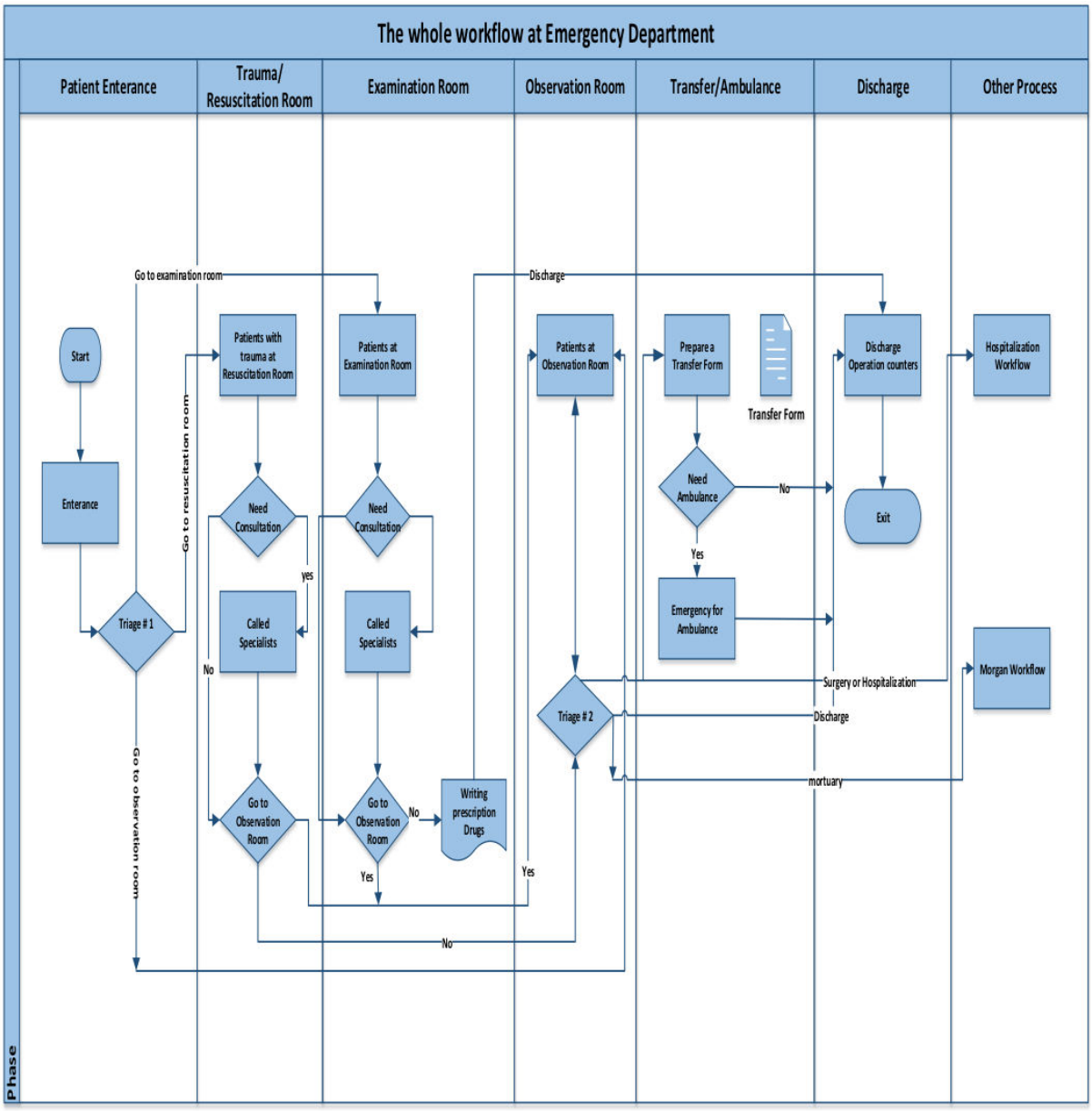

Figure 1. The Whole Workflow at Emergency Department

Patients arrive at ED entrance whether by own car or ambulance then going to the reception area to be checked by a triage nurse. The low acuity patients (Level 4-5-a) who require diagnosis go to reception to triage by a nurse, then start registration procedures by administrative registration clerks, sometimes they are asked to wait until diagnosis room becomes available. The emergency doctor starts diagnosis and calls a specialist if necessary. Doctors may need more diagnosis testing (i.e. lab testing or/and imaging testing); for imaging testing, patients move to "Radiology Department" RD then go back to ED to get the review results by a doctor who writes report or/and description drugs and giving guidance to the patient, then give a decision (discharge or admission to get more treatments or transfer to another hospital or transfer to OR).

The low acuity patients (Level 4-5-b) which require simple surgical operation or simple procedure; in most cases, this kind of operation and procedure is run by a nurse, after triaged by a nurse depending on their situation they are routed to reception, or to RR then go back to reception to complete discharge procedure.

After classified by the triage nurse, the emurgent patients (Level 2-3) are immediately routed to OR, a nurse typically records blood pressure, temperature, oxygen levels and assesses pain levels, at the same time, fills

historical data form with the patient or his/her family. The emergency doctor starts diagnosis process, in some cases, it is necessary to call a specialist to take a decision, sometimes patient needs more diagnosis testing; Lab Testing (sample taken at OR, then nurse carry the sample to Lab) and Imaging Testing (the patient move to Radiology Department, RD). Patients completed imaging testing procedure (X-Ray or/and Ultrasound) need to go back to ED to receive review results, they may need more treatments or drugs, they receive all necessary treatments, prescription drugs and any guidance from the doctor. Afterward, a final decision might be to discharge or admission to get more treatments or transfer to another hospital.

3.2 Value Stream Mapping

3.2.1 Data Collection and Analysis

In this study, real-life data of the length of stay (LOS) were collected through direct observation in a 2 months-period between 11:00 am and 4:00 pm. Management staff and doctors were informed and interviewed regarding the project and tasks to be held in the hospital.

The time of entry and exit of 83 patients, their routing between the departments and time they consumed at that departments were recorded. Sample data for the time consumed at RD for patients who required Imaging Test (X-ray, Ultrasound) was collected from 27 patients. Also, time spent by the patients to complete some administrative procedures within the emergency department such as Registration Process and Discharge Process and the time spent at the Waiting Area were collected and recorded in a similar way.

The average time, standard deviation and the distribution of observations for each process cycle time after removal of outliers were calculated. Normal Distribution is found to be best-suited for each operation, using Anderson-Darling statistic (A^2).

3.2.2 Current State Map "VSM"

Womack and Jones (1996) define the value stream as "the set of all the specific actions required to bring a specific product (whether a good, service, or increasingly a combination of the two) through the three critical management tasks of any business: the problem-solving task, the information management task, and the physical transformation task". VSMs determine how long each step in a process takes to complete, and the waiting time between process steps [22], [23].

Patients flow at ED is very complicated and many flow scenarios may happen for each product/service family. For this reason, the most repeated flow scenario is considered and the Current Value Stream Maps for each product/service levels are constructed. In this paper, we preferred to present VSMs for the emurgent, Level 2-3, process only.

As seen in Figure 2, when emurgent patients, Level 2-3, arrive, they immediately go to OR for diagnosis which takes about 45 min, are then routed to RD for an imaging test; they need to wait 2 min before the ultrasound process which takes about 7.36 min. Then they are routed to X-Ray Room (0.5 min) and the time consumed to finish X-Ray process is about 4.29 min on average. They go back to OR in 1.5 min and wait until results are ready and reviewed by an emergency doctor who may sometimes ask patients to take more treatments. This time is about 22.86 min. Having the report from the doctor, patients or their families are routed to finish discharge process which takes about 2.63 min. The LOS is 86.14 min on average.

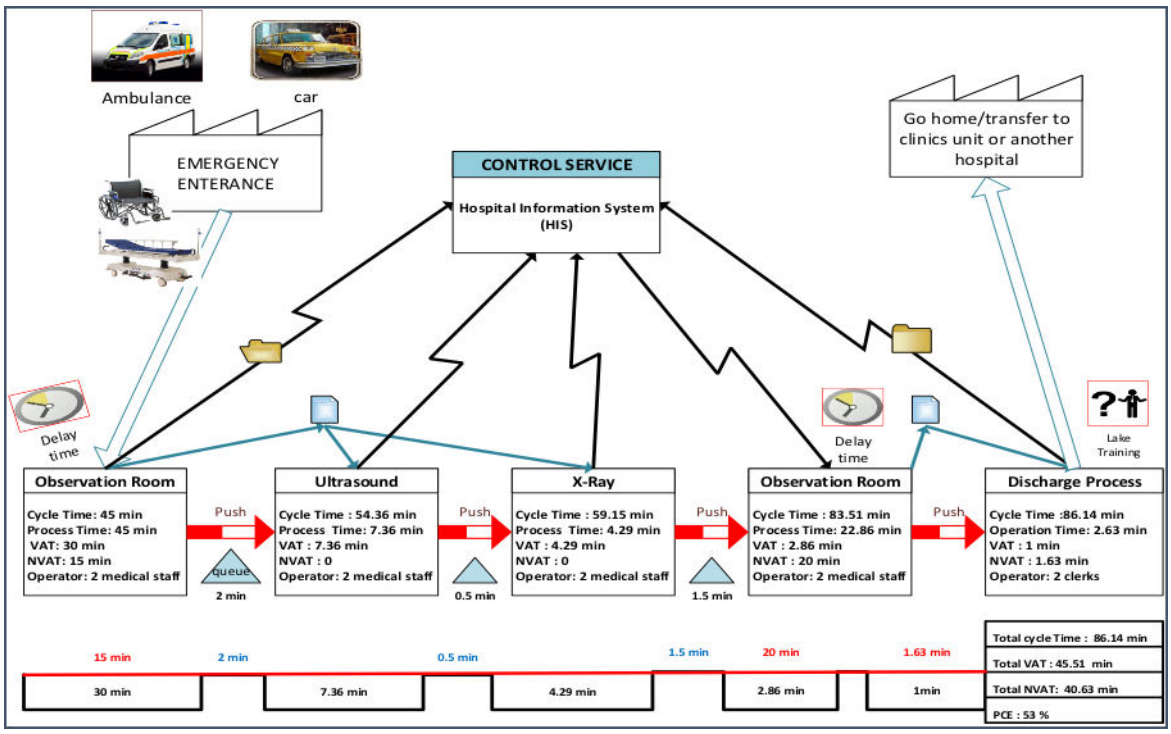

Figure 2. Current state value stream map of Level 2-3.

In this study, the Anylogic Software (AnyLogic 7 University 7.2.0) is performed to simulate Emergency Department System to identify the overall system and observe the improvement in the system. Real observations of LOS "of patients enter to the system until exit" were collected under the same conditions. To ensure the simulation model represents the real system and no significant difference exist in mean and variation "two-sample t-test" at a significance level of ($\alpha = 0.05$) is applied. The results revealed that the mean and the standard deviation of software data are not significantly different from the mean and the standard deviation of real observation; that means the simulation model represents the real system.

Arrival rate of patients at ED was defined 0.11 patient per minute, and the probability of each product family existing in the department was calculated such as the probability of Level 2-3 is 28%, the probability of Level 4-5-a needs diagnosis is 57.6% and the probability of Level 4-5-b needs simple procedures is 14.4%.

3.3 Create Flow

3.3.1 Value and Non-Value Added

In addition to the delay when patients in queues (waiting before a process), the delay when patients in the process (i.e. OR, ER, Discharge Process) was recorded. The non-value added activities (NVA) with their measured time were summarized in Table 1 with the percentage of time for each NVA activity to the total time of NVA activities. The Process Cycle Efficiency (PCE) of Level 4-5-a, Level 4-5-b, and Level (2-3) are found 31, 32 and 53%, respectively.

Table 1. Analysis of non-value added activities

Product/Service Family →		Level 2-3		Level 4-5-a need diagnosis		Level 4-5-b need simple procedures	
Process	**NVA activity**	Time (Min)	%	Time (Min)	%	Time (Min)	%
Registration process	Wait in queue			1.5	13.6	1.5	17.1
	Wait for clerk to finish registration process			0.13	1.2	0.13	1.5
Waiting Area	Patient need wait before entering to examination room			3	27.1	2	22.8
Examination Room	Wait for nurse to prepare equipment/devices and fill patient's historical data form			1	9.0		
	Wait for emergency doctor / on-call specialist to start diagnosis			1.30	11.8		
Resuscitation Room	Wait for nurse to prepare the tools/device					1	11.4
Observation Room	Wait for nurse to provide medicine and prepare facilities, equipment, and devices	6	14.8				
	Wait for emergency doctor and on-call specialist to start diagnosis	6	14.8				
	Wait for nurse to transfer the patient to RD	3	7.4				
	Wait for ultrasound results	10	24.6				
	Wait for doctor to review results and confirm diagnosis	5	12.3				
	Wait for doctor report with explanations and recommendations	5	12.3				
Radiology Department	Wait in queue	2	4.9				
	Transfer to X-ray room	0.5	1.2				
	Wait for radiology nurse to transfer patient to ER	1.5	3.7				
Discharge Process	Wait in queue			2.5	22.6	2.5	28.5
	Wait for clerk to prepare the bill, contact with insurance company and close the file of patient in HIS	1.63	4.0	1.63	14.7	1.63	18.6

3.3.2 Root Causes of Non-Value Added Activities

The NVA activities with high NVAT% for each product family and having a significant effect on more than one product family in Table 5 have priority for the analysis to identify the significant root causes of waste. Thus, based on Kaizen principles the root causes of waste were identified by direct observation and a lot of meetings, interviews, and discussions with all employees that have the most knowledge about activities at ED and RD. In addition, fishbone diagram was conducted to summarize the results of a brainstorming session for the root causes of NVA activities as shown in Figure 3.

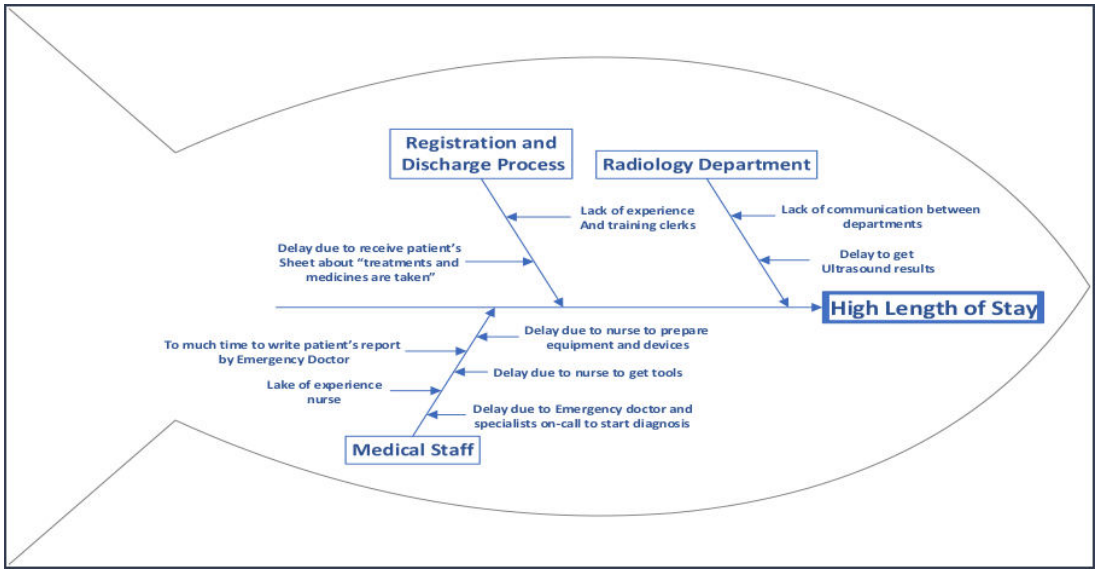

Figure 3. Fishbone diagram for the LOS of patients at Emergency Department.

3.4 Establish Pull / Kaizen

In this study, in addition to the direct observations, we also focused on employees' suggestions for improvements. Moreover, lean tools and the simulation model were used to implement the appropriate improvements. The countermeasures for improvements were discussed in followings:

1. Delay time at registration, discharge processes and in queuing before the services:
   - An adequate training program should be applied to the new employees to reduce the waste of time.
   - The patient's sheet module should be added to the medical order command in the Hospital Information System for all information necessary for discharge process. By this way, the department can reduce the waste of time to receive patient's sheet as well as avoid the written sheets and unreliable information.
2. It is necessary to redistribute the tools and medical supplies by an effective method in all emergency rooms to reduce wastage in time and motion, and at the same time reduce the stress of nurses. The 5S (sort, set in order, shine, standardize, and sustain) technique is very helpful and necessary in eliminating waste due to the disorganized workplace. Items used most often should be stored closest to the point of use. In addition, using visual methods to mark standard locations may help see easily if something is missing.
3. It is necessary to allow charge nurses to focus on their skilled work as it values their special abilities rather than focus on the administrative work. Regarding this, an experienced nurse skillful on administrative procedures should be employed or one of the nurses at the department should be trained under the supervision of a charge nurse. This may also lead to reducing delays at discharge process. The diagnosis process is shared with the Charge Nurse to make a diagnosis for patients with the normal repetitive situation and there is no need for emergency doctor intervention. To further eliminate patient's time of waiting, reduce the stress on the emergency doctor and avoid wrong triage by the nurse which leads to increase the waste of time the Charge Nurse should be more focused and take responsibility for the triage process. Further support of charge nurses on routing the patients to the appropriate Examination Room according to the resource requirements will avoid waste of time and transportation caused by a shortage of equipment in rooms.
4. To avoid waste of time due to lack of communication such as "isolated island" Kanban tool can be used to establish Pull System; A Kanban, "signal, card or sign", can be electronic signal that is sent by computer system from emergency department to radiology department to inform that the patient needs to make imaging signal and wait for the response from the Radiology Department when the room is empty. In this way, we can avoid the waste of time and more illness and fatigue caused by waiting. A portable ultrasound should be used, especially it is already available at the hospital, and call the ultrasound

technician by the same way to call the specialists at the hospital (i.e. patient can get ultrasound imaging at the same time obtained the parenteral nutrition).

5. It is very important to formulate the patient's report form by the medical staff, e.g. doctors and nurses, because it contains important details and this will reduce the time of filling the form.

Considering the brainstorming results and above-mentioned recommendations the emergency process was redesigned, its flow was redrawn, and the simulation model was run for the new process called future state value stream map (FVSM) as shown in Figure 5.

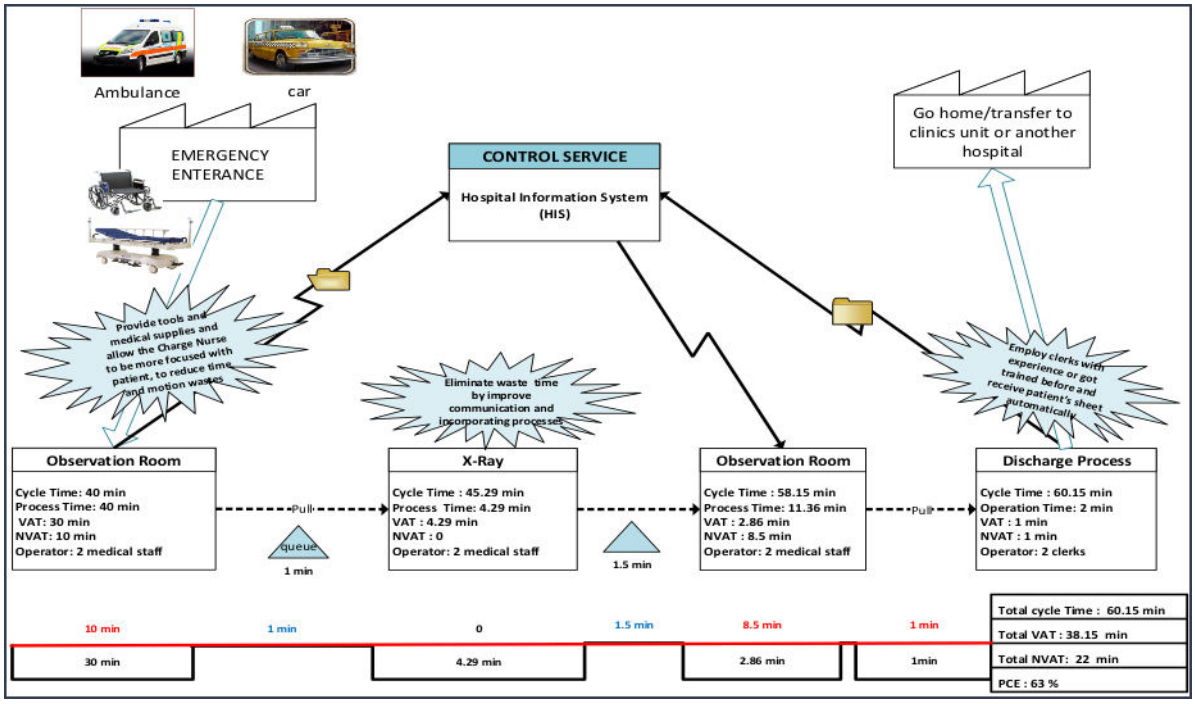

Figure 4. Future State Value Stream Map of Level (2-3)

The LOS was reduced from 86.14 to 60.15 minutes; the cycle time was decreased by 30.17%, and the standard deviation was reduced from 28.19 to 21.03 minutes. In addition, the Process Cycle Efficiency is improved by decreasing the cycle time through implement improvements from 53% to 63%. Similar improvements were achieved for level 4-5-a and level 4-5-b.

3.5 Seek Perfection

It is essential to construct the control policies to reduce variation in processes, achieve goal values and enhance the continuous improvement. These policies were proposed as follows:

- The employee who does a certain job should be the most knowledgeable person about it; workers should be provided with a healthy environment which helps them increase their ownership of the job, and the team efforts should be promoted towards change and innovation with the participation of all employees. Problems that are identified should be fixed right away when possible. If a problem is not being solved immediately, the planned action can be recorded on the audit sheet for communication and visibility purposes.
- It is better to measure performance metric of the LOS by patients, and when the time exceeds the goal (expectations of patients and employees) the unusual report should be proposed and hold the review meeting regularly; It can utilize the Hospital Information System to identify the LOS by patients at the department.
- Lean metrics could be made visual through the use of trend charts and color coding.

- To prevent the "5S" method from becoming a non-recurring case, it is essential to evolve a policy to sustain workplace improvement. Therefore, the 5S audit sheet should be prepared every month in order to support improvements.
- The value stream map for each product family should be plotted every six months to review the process details to enhance the pull system flow and reduce wastes in processes, if necessary, the process should be redesigned.

4 Discussion & Conclusion

The implementation of lean methodology in the healthcare sector is an area which has attracted the interest of practitioners and researchers to improve the performance of medical services. This study was also aimed to improve quality and productivity of healthcare processes through lean production initiatives by focusing on human value rather than products only.

One of the challenges in this study is the work in an emergency department which is the most complicated part of the hospital because different patients' requirements depend on each patient's situation so there are different flows with different time cycles and processes. By taking advantage of the product family idea in lean manufacturing which is another contribution to the study; the patients represented as service/products to identify patient families at emergency department based on triage process by using the Emergency Severity Index (ESI). Moreover, from the study it is evident that simulation model is an effective, and methodology will help in gearing up the process by eliminating root causes of the problem, and reducing the length of stay of patients. This will lead to increase the turnaround in the emergency rooms and increase of the satisfaction level of the patients and employees. The effectiveness of the lean projects in health care can be increased by the integration of simulation; many of the risks in the adjustment of an existing system can be avoided, and possible improvements can be observed in a very short time. In this study, the positive results mentioned earlier in the methodology confirmed the decreasing in the length of stay (LOS) of patients and increasing the process cycle efficiency. Hence, this will lead to the increase in the satisfaction level of patients and the medical staff. Therefore, the novelty of our study is applying lean methodology with taking the advantage of product family idea and using simulation model to implement improvements. Clearly from our results, Lean method has emerged as an important methodology in investigating and reducing the wastes in the flow cycle of patients at Emergency Department.

As a sequel of the work to gain more customers and keep existing customers, it is important to study costs besides reducing the LOS at the hospital. Moreover, the patient volumes increase during the winter months because certain illnesses are more prevalent, and in particular during the day shift. Since patients will suffer longer delays when the demand is high, a further study to level the workload may be needed.

It is important to mention the shortage points in this study, which could be included in a future study, as follows: the limits of time the Level 1 is not considered, and the most repeated flow scenario is taken into consideration for each product family and the other flows were neglected. Furthermore, the simulation model could be used to show further analysis such as the bottlenecks in the system, as well as the utilization percentage of the rooms and medical staff.

Finally, the main barriers to implementation of lean methodology at the hospital in this study were: difficulty in obtaining baseline data on process performance; especially there is no record of the time consumed by patients at the hospital and the lack of both information exchange between employees and management, and the improvement culture.

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Biographies

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