Lean Management for Improving Hospital Waiting Times – Case Study of a Vietnamese Public/General Hospital Emergency Department

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Emergency departments (EDs) at public hospitals in Vietnam typically face problems with overcrowding, as well as being populated by a wide variety of illnesses, resulting in increasing dissatisfaction from patients. To alleviate these problems, we used the increasingly popular value-stream mapping (VSM) and lean strategy approaches to (1) evaluate the current patient flow in EDs; (2) identify and eliminate the non-valued-added components; and (3) modify the existing process in order to improve waiting times. Data from a total of 742 patients who presented at the ED of 108 Military Central Hospital in Hanoi, Vietnam, were collected. A VSM was developed where improvement possibilities were identified and attempts to eliminate non-value-added activities were made. A range of issues that were considered as a resource waste were highlighted, which led to a re-design process focusing on prioritizing blood tests and ultrasound procedures. On the administrative side, various measures were considered, including streamlining communication with medical departments, using QR codes for healthcare insurance payments, and efficient management of X-ray and CT scan online results. By implementing a lean approach, the following reductions in delay and waiting time were incurred: (1) pre-operative test results (for patients requiring medical procedures/operations) by 33.3% (from 134.4 minutes to 89.4 minutes); (2) vascular interventions by 10.4% (from 54.6 minutes to 48.9 minutes); and (3) admission to other hospital departments by 49.5% (from 118.3 minutes to 59.8 minutes). Additionally, prior to the implementation of the lean strategy approach, only 22.9% of patients or their proxies (family members or friends), who responded to the survey, expressed satisfaction with the ED services. This percentage increased to 76.5% following the curtailment of non-value-added activities. Through statistical inferential test analyses, it can be confidently concluded that applying lean strategy and tools can improve patient flow in public/general hospital EDs and achieve better staff coordination within the various clinical and administrative hospital departments. To the authors' knowledge, such analysis in a Vietnamese hospital's ED context has not been previously undertaken.

Keywords: lean strategy; value-stream map; hospital information systems; accident and emergency department.

Introduction

Historically, in healthcare organizations in Vietnam, there has been an ongoing challenge of accommodating an ever-increasing number of patients attending public/general hospital emergency departments (EDs) despite a shortage of medical staff. This has resulted in an increasing demand for improved patient safety and quality of healthcare provision. Consequently, hospital management personnel resorted to stretching their resources, while simultaneously striving to improve patient satisfaction. An alternative approach, based on lean thinking and strategy, has recently gained popularity amongst healthcare managers in various general hospitals in Vietnam, and especially at the renowned public 108 Military Central Hospital in Hanoi.

The issue of overcrowding at Vietnamese public hospitals has always been considered a norm for many healthcare providers to manage. The waiting time for outpatients varies from one central hospital to another. It was reported that, in 2012, the average time that a patient spent from registration to medical completion was 246.87 ± 104.55 minutes (Tran et al., 2017). According to the study conducted by Nguyen et al (2018), the mean total waiting time was 104.1 minutes for outpatients at one of the largest national hospitals in Vietnam.

Lean Management

Lean thinking is a philosophy that focuses on eliminating waste or non-value-added elements from processes so that customers are given greater value (Wickramasinghe et al., 2014). It originated from the automobile industry where it has been applied successfully (Alowad et al., 2020). Many hospital ED units in the USA, UK and other

countries have successfully applied the lean concept (Holden, 2010). Therefore, a number of EDs in developing countries, such as Vietnam, have also begun to apply the lean methodology as a way to overcome the problems of overcrowding and delays resulting from activities associated with long waiting times.

As mentioned above, lean thinking and tools can provide insight into identifying non-value-added and time-wasting processes so as to streamline patient flow in emergency departments. Value and flow are key concepts of the lean approach (Lot et al., 2018). Value in healthcare encompasses the activities that enhance the quality of healthcare provision and promote patient well-being, thus leading to improved health outcome. Inherently, healthcare consists of a variety of patient-centred outcomes through which value imparted to the patient is the ultimate goal. In the context of healthcare, value refers to whether the treatment experience was worthwhile, that is whether it met the patients' needs and satisfied them from a cost-time viewpoint.

According to a study led by Miller and Chalapati (2015), waste can be defined as any activity that does not positively assist patients on their journey towards recovery. One of the salient wastes in an ED is the idle time spent waiting – for example the waiting time to be attended to or the unnecessary delay in administering subsequent treatment. When waste is removed, patient-flow becomes smoother and seamless. This inevitably increases the efficiency, quality and safety of patient care (Kruskal et al., 2012). Also, as a result of streamlined flow in healthcare processing, patients' demands are fulfilled in an effective and efficient way. All necessary measures should, therefore be taken to create a value flow devoid of delays, interruptions, backflows and shortcomings. That is, the goal of optimized flow is to eliminate queuing, interruption and waiting within a process.

Value Stream Mapping as a Lean Management Tool in EDs

Value stream mapping (VSM) is a field-based tool in the area of lean management that has witnessed growing importance in ED departments in the developed countries, including the USA, UK, Spain, Sweden and Ireland (D'Andreamatteo et al., 2015; Nowak et al., 2017; Persis et al., 2020; Marin-Garcia et al., 2021). The positive impacts of the use of VSM in the healthcare industry have been evidenced. For example, in general, implementing VSM during an observation period helps to improve the operational sides of healthcare quality through improving patient length of stay, waiting time (Cooke et al., 2002; King et al., 2006; Sayed et al., 2015), work engagement (Ramaswamy et al., 2017) and transportation within hospital confines (Chiarini, 2013).

Considering a recent comprehensive survey of healthcare services in developing countries, such as Brazil, Turkey or Kenya, Kelendar et al. (2020) identified 14 studies published between 2000 and 2018, which were related to lean methodologies in healthcare settings. In those studies, the salient means of analysis relied on VSM. However, with respect to Vietnam, no such study was ever undertaken in accident and emergency departments and no publications related to VSM implementation in hospital settings were included in Kelendar et al.'s review. Equally, other recent systematic review studies published by Vidal-Carreras Pilar et al. (2016) and Lima et al. (2021) did not pinpoint any publication related to the use of VSM in healthcare services in Vietnam.

According to two systematic review studies by Nowak et al. (2017) and Marin-Garcia et al. (2021), VSM is a method that enables the analysis of hospital workflow and, subsequently, assists in visualizing complex processes and quantifying patients' needs in order to improve waiting times, increase work engagement and reduce work

movement. In this study, these were all outcomes that were measured to assess patient satisfaction levels at the operational levels of EDs.

Within a problem-solving context, VSM is fused into the five (5) phases of lean strategy, namely, *Define*, *Measure*, *Analyse*, *Improve* and *Control* (DMAIC) to generate VSM-DMAIC models (Guo et al., 2019). When applied in EDs, the DMAIC phases provide insights into patients' length of stay and thus VSM becomes a tool to map and visualize a patient's journey from the point of hospital admission to that of transferring to other departments or discharge. The study conducted by Persis et al. (2020) reported the use of a combination of these two tools in order to improve patient turnaround time and organizational profits in the cardiology department of a multi-speciality hospital in India.

Based on this premise, this study has set out to evaluate the impact of lean principles on the length of patient attendance in the ED from the time of registration to the time of either undertaking any further urgent medical intervention or transferring to other clinical departments of the general 108 Military Central Hospital in Hanoi, Vietnam. Patients who got completely discharged from the ED were not considered; the target was to improve the waiting time of patients who needed further action within the hospital. In other words, the aim was to improve the coordination between the ED and other departments. For this purpose, we used the increasingly popular approach of "lean strategy", which consists of the DMAIC processes, while using VSM as a visualization tool to chart the journey of patients admitted into the ED of that hospital. The entire process workflow was examined in order to (1) evaluate the current patient flow in the ED, (2) identify and eliminate non-value-added processes, and (3) modify any disparaging existing practices.

Methodology

Study Design and Setting

This is a quantitative study with pre- and post-lean design carried out in the emergency department of a governmental hospital, namely the 108 Military Central Hospital, providing medical care to the residents of Hanoi, the capital of Vietnam, which has a population of approximately 9 million (Ha et al., 2020). Medical services are provided on a 24/7 basis, and the ED is structured on the basis of the Manchester Triage System (MTS), where there are 5 main zones: Emergency, Very Urgent, Urgent, Slightly Urgent and Non Urgent (Azeredo et al., 2015). The Emergency zone has a capacity of 5 beds, while the remaining 4 zones have a maximal capacity of 15 beds, each (Table 1).

[Table 1. Details of Standard Waiting Times and Capacities at the 108 Military Central Hospital ED]

Although the ED comprises 5 zones, only 3 zones (red, yellow and green) were taken into consideration when implementing the lean strategy study. The majority of admitted cases to these zones were adult patients, aged 16 years and older. In order to evaluate process flow and reduce waiting times, the five-phase DMAIC problem-solving approach (described in more detail in a later section) was derived. In December 2018, prior to the lean strategy implementation, an initial assessment was undertaken of the workflow and time sequence of each emergency procedure. This was repeated again in April 2019, following the implementation of the lean strategy.

In order to explore patient satisfaction in terms of waiting time, the project team distributed surveys using a systematic sampling method, whereby on every Monday and

Saturday between 08:00 and 21:00, patients who were about to complete their ED journey, or their companions, were handed a paper-based questionnaire (Table 2).

[Table 2. Satisfaction Survey Questionnaire]

Participants were randomly selected and requested to answer the questionnaire within 2 weeks. Descriptive analyses and inferential statistics were used to assess the changes in service satisfaction pre- and post-lean strategy implementation among patients who were admitted to the ED, or their companions as proxies.

Lean Strategy Implementation

Define

In this first stage, the ED management team held 16 meetings with other hospital departments' managers in order to discuss various relevant issues. Waiting times to collect medical test results and undergo consultations with specialists were the prominent issues with the highest dissatisfaction level, as evidenced from the results of the initial questionnaire, which was acquired from 96 patients, or their companions, who attended the hospital's ED within a period of two weeks in December 2018.

In order to identify an appropriate sample size, the standard formula, below, was applied, based on setting a confidence level of 95% and assuming a 0.1 margin of error. For this study, due to time and financial constraints, such error margin was deemed acceptable according to the study by Suresh and Chandrashekara (2012):

$$n' = \frac{\frac{z^2 * p * (1 - p)}{\varepsilon^2}}{1 + \frac{Z^2 * p * (1-p)}{\varepsilon^2 * N}}$$

In this equation, the various parameters are defined as follows:

Z	Z-score – 1.96 (value for 95% confidence level)
p	Proportion percentage
N	Population size (based on the fact that, in 2018, 34,333 patients attended the ED).
ε	Confidence interval or margin of error in percentage

The result of the survey demonstrated that over 77% of patients or companions visiting the ED were not satisfied, and advocated the necessity of improving the various wasteful waiting times.

With no patient outright discharge subsequent to attending the ED being considered, the process flowchart of Figure 1 illustrates the general patient pathway following presentation. It included 5 different stages: (1) presentation and registration at the ED, (2) evaluation by ED physicians and/or other healthcare professionals, (3) collection of test results, (4) based on test results, further specialty investigations carried out, and (5) completion of patient record at the ED and referral for medical procedure or vascular intervention, or transfer to other departments for further diagnostic/clinical assessments.

The workflow and time sequences within one day (from 07:00 to 23:59) were then analysed with the use of time determinants of patient flow in the ED; these included the registration time, consultation time, locating insurance schemes and profiles time, conducting tests, collecting tests, additional consultation by specialists, and further admission to other hospital departments.

[Figure 1. 108 Military Central Hospital ED Pathways]

Based on the value-stream map, which was designed in the Vietnamese language and presented in Figure 2, time determinants were measured. These were subsequently documented (in English), as shown in Figure 3, in order to quantify the amount of value-added and non-value-added time in each step of the patient's journey.

[Figure 2. VSM for the 108 Military Central Hospital ED (in Vietnamese)]

[Figure 3. Time Determinants of Patient Flow at the 108 Military Central Hospital ED]

Measure

Various measurement techniques were used to analyse the existing system and comprehend the current state of the process (Montgomery, 2019). The reception desk nurses recorded all required information pertaining to each patient arriving at the ED. This information included personal details, insurance information, vital signs, historical health information, arrival time, triage category, zone attendance time, classification and departure time. It was saved in the ED data collection database, from which the required data for the present study were retrieved. It should also be noted that this study excluded patients who died in the ED.

Unless the patient was being discharged, following presentation at the ED, without any further necessary intervention, there were 3 outcomes that determined the estimated bed occupancy and consequent waiting times:

- Patient requiring medical procedure/operation. It was measured from the time of registration until undergoing the medical procedure/operation.
- Patient requiring vascular intervention. It was equally measured from the time of registration until undergoing the vascular intervention.
- Patient requiring admission or transfer to another clinical department. It was also measured from the time of registration until admission to another department.

Based on Figure 3, a total of 15 different steps affected the waiting time, and following the definitions outlined by Rahman and Karim (2013), *added-value activities*, which comprised steps (2), (4), (5), (6), (8), (9), (10), (11), (13), and (14) were identified; so were *necessary non-value-added activities*, comprising steps (1), (7), (12), and (15); and an *unnecessary non-value-added activity* (3).

During the period February-April 2019, a series of lean management steps were implemented to improve the waiting time for admission and collection of test results. The process was redesigned to minimize, or completely eliminate, any wastage. This consisted of the introduction of a structured redesign process, the enhancement of communication between administrative staff (back-door operators) and nurses, and the deployment of more effective procedures of collecting test results.

The data were analysed via the Statistical Package for Social Sciences (SPSS), version 21.0. In order to quantify the differences between the pre- and post-implementation of the lean strategy, various inferential statistics tests were utilized. To identify statistical significance in the means of two independent groups, Student's independent two-sample t-test, Mann Whitney U test and Aspin-Welch's unpaired t-test were used in this study. While Student's t-test applies when the two groups follow a normal distribution and have equal variances and sample sizes, the Mann Whitney U test is used when the assumption of normality distribution is violated and Aspin-

Welch's corrected unpaired t-test applies when the two groups do not possess a similar variance and sample size (Whitney, 1997; Marusteri & Vladimir, 2009; Rochon et al., 2012). To maximize the distinction power with the same significance level (alpha = 0.05), the project team endeavoured to recruit a nearly equal sample size for the two groups (Kim & Park, 2019). To be precise, the ratio between the two groups in the medical procedures/operations cohort was 1:1 (117:117) and in the vascular interventions cohort, 0.99:1 (118:119). The only disproportionate ratio pertained to the pre- and post-lean strategy implementation cohorts transferring to other clinical departments; in that case it was 0.76:1 (117:154).

In terms of normality assumption, there are various schools of thought relating to this issue when examining the means between groups. The conventional thought advocates that if the assumption of normal distribution is violated, the t-test result yields a reliable conclusion (Bernard Rosner, 1995; Nishishiba et al., 2014). However, Lumley et al. (2002) argued that, in the healthcare domain, the power of the t-test is still valid for large datasets even if the normal distribution assumption is not statistically satisfied. On this basis, this study with a total sample of 742 participants was considered large. This enabled the project team to draw conclusions even though some subsets of datasets included non-normal data. To ensure the validity of this approach, the team additionally decided to check the distribution of data using Shapiro-Wilk's normality test.

With regard to sample size, since the project included two main phases, namely, pre- and post-implementation of the lean strategies, the project team sought to survey the satisfaction levels of patients, or their companions, who presented at the ED during both phases. As outlined earlier, a satisfaction survey response was acquired from 96 patients, or their companions, who were randomly selected within a period of 2 weeks, prior to implementing any lean measures. By the same token, the post-lean

implementation satisfaction survey included 51 patients or their companions. In addition to this satisfaction survey, the three main flow pathways pertaining to the overall 742 patients, who were included in both phases, were also mapped in order to assess the changes that incurred from pre- to post-lean strategy implementation. A complete breakdown of the sample distribution is given in Table 3.

[Table 3. Pre- and Post-Lean Strategy Implementation Sample Distribution]

Analyse and Improve

According to the preliminary evaluation of patient flows, and considering all three outcomes (medical procedure/operation, vascular intervention and transfer to other departments), it was found that the most time-consuming processes were the delays associated with collecting test results (mean: 34.6 minutes, maximum: 49.5 minutes) and consultation by a specialist (mean: 32.43 minutes, maximum: 135.8 minutes).

Regarding the delay incurred in the collection of test results, the main issue lied in the insurance payment system. Although the layout of the registration zone had already been redesigned and the insurance information had been logically indexed for easy access, nonetheless manual checking of the health insurance identification number, as well as cash payment, remained excessively time consuming. Consequently, the management team decided to upgrade the payment system, enabling patients to settle their ED charges through the use of a QR code. This, in turn, allowed nurses, administrators and back-door operators to conduct automatic searches. Moreover, a one-time advance-payment prerequisite was also implemented in order to avoid multiple overlapping payments, as well as to reduce the number of time-consuming cash payments.

With regard to waiting time for specialist consultation, the main issue lied in the updates of various test results, including (1) X-ray and Computed Tomography (CT) scan tests, (2) ultrasound tests, (3) blood tests, and (4) pre-operative waiting time for specialist assessment. For X-ray and CT scan tests, the management team updated the Hospital Information System (HIS) software to allow specialists to scan medical results on the hospital's network. This assisted in avoiding the delay associated with the results being manually provided by the patients. Moreover, training on the ED patient flows for specialists from other departments was conducted. For the ultrasound laboratory, the management team decided to enable staff to work on a shift basis in order to maximize its capacity. Simultaneously, special training for radiologists was provided in order to enhance their clinical and technical skills. This assisted in a reduction of the diagnostic reporting times. For blood tests, on the other hand, and in the absence of focused procedures to prioritize ED patients, the management team, therefore, worked in tandem with the departments of biochemistry, haematology, immunology and blood transfusion to design a special process flow to collect blood samples for ED patients with an improved mechanism that can more rapidly return results.

Control

Following the implementation of the lean management steps that started in January 2019, a comparison was performed between the initial pre-lean ED patient flow analysis in December 2018, based on an attendance population of 352 patients, and that of a post-lean ED attendance population of 390 patients in April 2019. As mentioned earlier, these patients were admitted to the ED in order to undergo (1) vascular intervention and/or (2) urgent surgery, and/or (3) admission for further clinical treatment. Table 4 demonstrates the fact that, following the implementation of the lean strategy, the waiting time for medical procedures/operations was reduced by 33.3%, the waiting time

for vascular interventions was shortened by 10.4% and the waiting time for transfer to other clinical departments was reduced by 57.3%. Table 5 gives a breakdown of the waiting time pertaining to each of these activities.

[Table 4. Waiting Time Comparisons Between Pre- and Post-Lean Strategy Implementation Periods]

[Table 5. ED Waiting Time Breakdown, in Minutes and by Activity, Pre- and Post-Lean Strategy Implementation]

Auxiliary Results

Inferential Test Results Pre- and Post-Lean Strategy Implementation

Considering the results outlined in Table 4 for the waiting time of patients who required medical procedures/operations, it can be concluded that the mean waiting time of 134.4 minutes, calculated prior to implementing the lean strategy, reduced to 89.4 minutes following its implementation. Confidence in this conclusion was gained due to Student's independent sample t-test showing a significantly small p-value [$t(df = 232) = -9.9695$, $p < 0.05$]. For this cohort, because the normality assumption was not satisfied, the Mann-Whitney U test [$W = 1783.5$, p-value < 0)] was applied and it confirmed the validity of Student's independent sample t-test.

For those who required vascular interventions, a similar conclusion can be made, where the mean waiting time of 54.6 minutes, prior to the implementation of the lean strategy, reduced to 48.9 minutes post-lean strategy implementation. This is corroborated by Student's independent sample t-test yielding a small p-value [$t(df = 236) = -4.9939$, $p < 0$)]. For this cohort, the assumption of normality was satisfied since

the Shapiro-Wilk normality test [W = 0.92373, p-value ≈ 0.00] yielded a p-value < 0.05.

Finally, for those who were admitted to the ED but eventually got transferred to other hospital departments, the inferential results also illustrated that there was enough evidence to conclude that the mean waiting time of 59.8 minutes, post-lean strategy implementation, was significantly less than that prior to its implementation (118.3 minutes). This was evidenced through Student's independent sample t-test yielding a significantly small p-value [t(df = 269) = -10, p < 0.05]. For this cohort, the assumption of normality was satisfied since the Shapiro-Wilk normality test results [W = 0.9, p-value ≈ 0.00] yielded a p-value < 0.05. However, since the two groups did not have an equal size, Aspin-Welch's corrected unpaired t-test was also utilized. The results of that test [W= 2177.5, p-value ≈ 0.00], for which the p-value is smaller than 0.05, confirmed the validity of Student's independent sample t-test.

Satisfaction Survey Results

Overall satisfaction of patients or their companions was assessed through the 3-level Likert scale outlined in the survey questionnaire (Table 2). This was carried out twice: in 2018, prior to implementing the lean strategy approach and, again, in April 2019, following its implementation. Of the 96 pre-lean strategy implementation people surveyed, only 22 patients or companions (22.9%) expressed their satisfaction with the service that they experienced during their journey through the ED department. This percentage significantly increased to 76.5% (39 out of 51 people) who completed the questionnaire post-lean strategy implementation and curtailment of non-value-added activities.

Other issues related to patient satisfaction were not included in this paper since the focus here has solely been on the level of satisfaction of patients or their proxies.

Discussion and Conclusion

The number of patients presenting at the emergency department of 108 Military Central Hospital in Hanoi, Vietnam, has been gradually increasing in recent years. In 2016, there was a total of 42,598 patients presenting at the hospital, of whom 22,082 attended the ED. In 2018, these numbers climbed to 60,146 and 34,333, respectively. This meant that, prior to implementing the various lean strategies outlined earlier, there was a 41.2% increase in the overall number of patients attending the hospital, with a 55.5% increase in ED patients, specifically. Patients who needed a medical procedure/operation spent, on average, 134.4 minutes waiting for their operation; patients who required vascular intervention spent, on average, 54.6 minutes waiting for their intervention; and patients who waited for referral to other clinical departments incurred a delay of 118.3 minutes until they were actually transferred. Most of these patients had to wait for the completion of each of the following steps: registration, general consultation, healthcare insurance identification and processing, various tests, specialist consultation, transfer instructions and/or other procedures.

Generally, from a patient's perspective, most of the various processes are considered to be, both, wearisome and time-consuming. Therefore, understanding what patients really want and improving patient flow in the ED are significant factors affecting patient satisfaction and quality of healthcare service.

This study asserted that a structured and redesigned lean process can effectively reduce the waiting time related to test results collection and provision of specialist consultation. This included the reorganization of the layout of the registration zone,

increase in the number of staff collecting and returning blood test samples and results, and the redesign of the admission process at the biochemistry, haematology, immunology and blood transfusion departments in order to prioritise ED patients. We demonstrated that an extensive reorganisation of physical layout and coordination between departments can effectively improve patient flow in the ED.

The increase in admission waiting time, total processing time and length of stay in the ED can be explained by a number of factors. A patient's disease severity, combined with significant co-morbidities, would inevitably increase therapeutic complexity and result in multiple necessary interim activities. More diagnostic investigations and time-consuming procedures would have to be performed. As a result, the medical admission waiting time, total processing time and length of stay in the ED would be lengthened.

To address such issues, hospital administrators made significant efforts to solve the aggregate problem of ED overcrowding and waiting time. In order to streamline the distribution of test results between various specialities in different departments, as well as physicians in the ED, they were made available on the local network of the hospital with proper access authorization levels. In particular, ED-requested blood tests were separated from those of other patients in the hospital and given a higher priority. This meant that laboratory personnel were able to record and divulge the results within a short time span. Additionally, images relating to the various tests were also electronically attached to the system. Such simple measures contributed to a significant reduction in lab test information sharing.

Notwithstanding the above advantages, several limitations have to be considered when interpreting the results accrued from this study. First, the data used may not be generalized across other EDs of public hospitals in Hanoi due to the short study period,

relatively small sample size and single study site. Besides, the study attempted to evaluate a real process in the ED environment, which is uncontrolled. Patients arrived at variable rates, with unpredictable needs, creating a high level of uncertainty, and attendance for emergency services exhibited ad-hoc patterns. Therefore, the state of flux of the ED environment may have an influence on this study's findings. Moreover, selection bias that may have been introduced by the convenience sampling could be another limitation.

Nonetheless the results of this study implied that there were some areas worthy of improvement. For example, blood test processes include their physical collection and transportation by porters from the ED to the appropriate laboratories. The same principle applies to test results which are being manually ported back to the ED. When porters are engaged with other tasks in various areas of the hospital, patient flow in the ED gets inevitably hindered, with a consequent increase in waiting time. Thus dedicated ED-based porter services would alleviate this problem and contribute towards a more streamlined and efficient process. Moreover, software for the electronic transfer of medical records could be developed to further decrease undue wastage in time.

In conclusion, this study could hopefully inspire ED managers to achieve significant improvements through better strategies and relatively simple lean process implementation measures. Reducing unnecessary delays in the ED undeniably ensures improved patient outcome and the application of a lean approach can streamline patient flow within the emergency department. Therefore, a systematic adherence to the principle of lean management can be crucial to the provision of high-quality emergency care and patient satisfaction. We believe that lean management strategies should be developed with the participation of frontline healthcare professionals, partaking in such change process, in order to ensure improved overall ED process flow.

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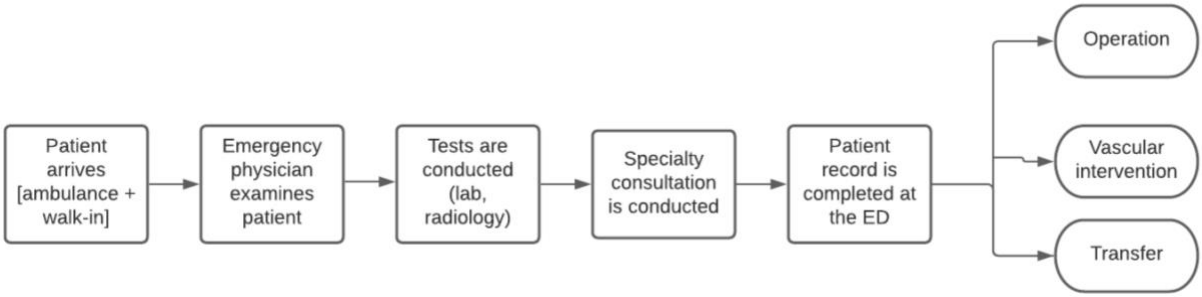

Figure 1. 108 Military Central Hospital ED Pathways

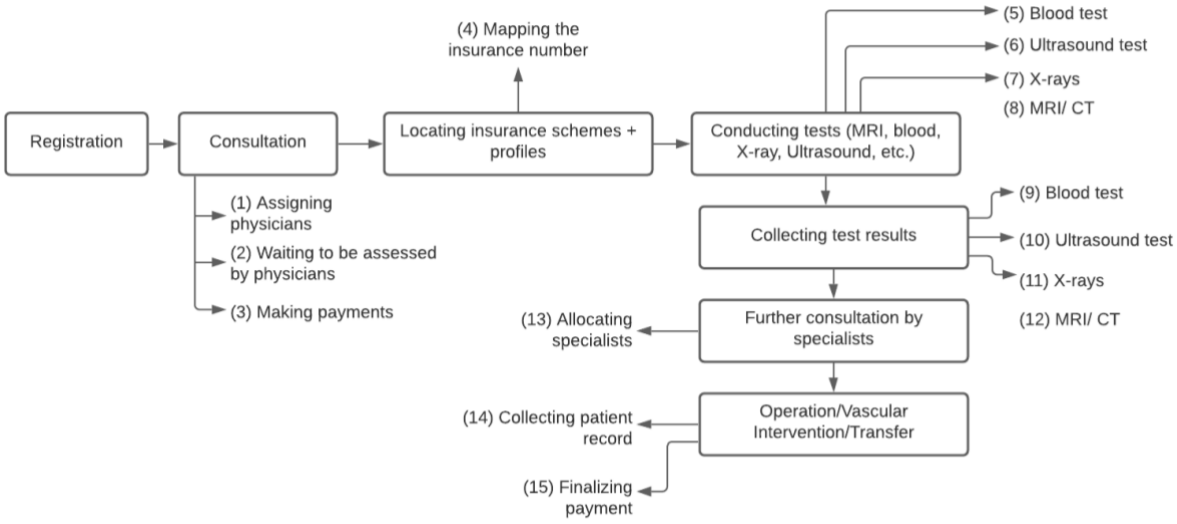

Figure 2. Time Determinants of Patient Flow at the 108 Military Central Hospital ED

Table 1. Details of Standard Waiting times and Capacities at the

108 Military Central Hospital ED

Zone	**Standard waiting time of MTS**	**Capacity**
Emergency - Red	Within 5 minutes	Maximum of 5 beds
Very urgent - Yellow	Within 60 minutes	10 to 15 beds
Urgent - Green	Within 2 hours	10 to 15 beds
Slightly urgent - Blue	Within 4 hours	10 to 15 beds
Non urgent		10 to 15 beds

Table 2. Satisfaction Survey Questionnaire

Dear Patients and Companions:

This survey is conducted in order to improve the ED service quality. We would like to hear your opinion about the service you received in this ED of the 108 Military Central Hospital. Your responses will be treated with the utmost confidentiality.

Thank you for your time.

1. On average, how long did you wait before seeing a doctor?
    a. 30-60 min
    b. 60-90 min
    c. 90-120 min
    d. Over 120 min

2. Did nurses notify you about your waiting time?
    a. No
    b. Yes
    c. Don’t remember

3. Are you satisfied with the ED service that you received?
    a. Not satisfied
    b. Neutral
    c. Satisfied

4. Would you recommend this ED to others?
    a. No and why…….
    b. Yes
    c. Don’t know

5. According to you, what can this ED do in order to improve its services?

Table 3: Pre- and Post-Lean Strategy Implementation Sample Distribution

ED Pathways	Pre-Lean (%)	Post-Lean (%)	Total (%)
Medical procedures/operations	117 (33.2)	117 (30.0)	234 (31.6)
Vascular interventions	118 (33.6)	119 (30.5)	237 (31.9)
Transfer to other clinical departments	117 (33.2)	154 (39.5)	271 (36.5)
Total	**352 (100)**	**390 (100)**	**742 (100)**
Satisfaction Survey	96 (27.3)	51 (13.1)	147 (19.8)

Table 4. Waiting Time Comparisons Between Pre- and Post-Lean Strategy Implementation Periods

	Waiting time (minutes)			
	Pre (mean ± SD)	Post (mean ± SD)	p-values (95% CI)	Changes (minutes / %)
1 - Medical procedures/operations	134.4 ± 37.3	89.4 ±31.5	< .005 95% CI [-54, -36])	-44.6 / 33.3%
2 - Vascular interventions	54.6 ± 11.1	48.9 ± 5.5	< .005 95% CI [-Inf, -4])	-5.7 / 10.4%
3 - Transfer to other clinical departments	118.3 ± 50.5	59.8 ± 47.5	< .005 95% CI [-70, -47])	-58.5 / 49.4%

Table 5. ED Waiting Time Breakdown, in Minutes and by Activity, Pre- and Post-Lean Strategy Implementation

Parameters	Medical Procedure/Operation		Vascular Intervention		Internal Transfer	
	Pre	Post	Pre	Post	Pre	Post
Mean						
Presentation	10.5	7	9.8	9	12	10.5
Examination	15.7	10.8	10.8	10.2	16	8
Tests	48.8	38	14	11.5	41	15
Consultation	49	23.6	11	10	37.3	21
Completion	10	10	9	8.2	12	5.3
Min						
Presentation	4	3	3	3	4	5
Examination	14	8	9	8	3	8
Tests	11	7	7	7	0	0
Consultation	13	10	10	13	2	5
Completion	3	3	3	3	2	2
Max						
Presentation	9	8.5	9.5	8	9	9
Examination	49.5	50	15.5	14	47.4	46
Tests	131.2	92.5	31	24.6	132.5	136
Consultation	135.8	123	16	11.4	135.8	138
Completion	25.5	26	3	3	6.3	6